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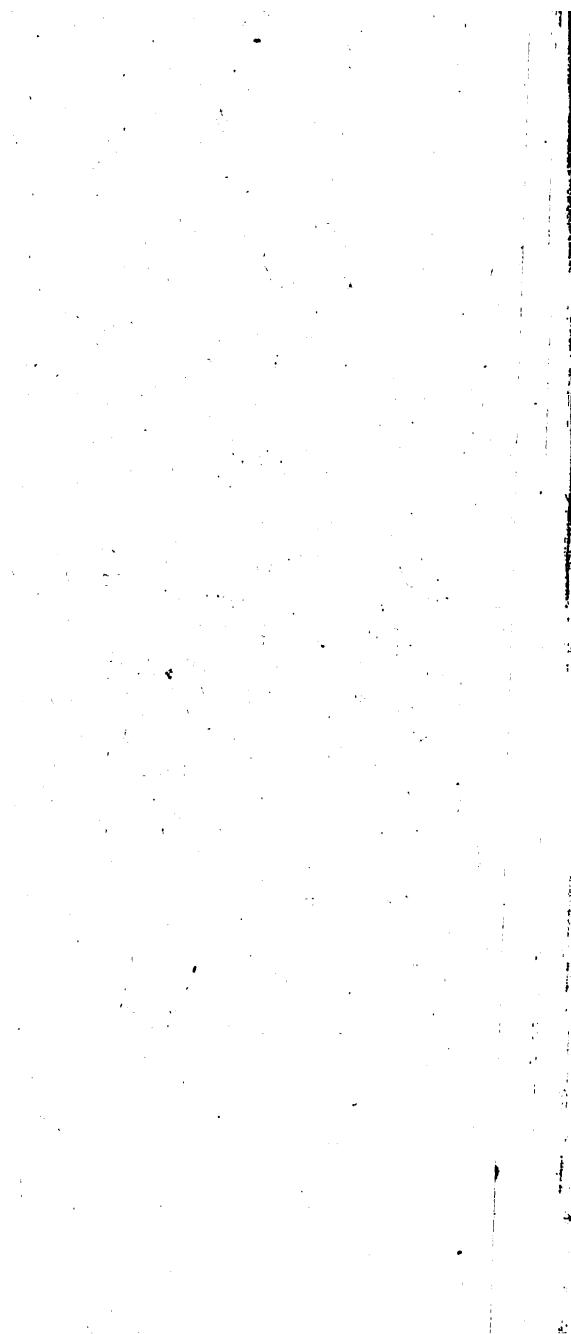
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ADVANCED TEXT-BOOK
OF
PHYSICAL GEOGRAPHY



...the importance, not merely in its bearings on
the human mind, but on the intellectual advance-
ment of the world. It is a knowledge
of the human mind, which are linked together and made
the perception of these relations
...the human mind.

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ADVANCED TEXT-BOOK

OF

PHYSICAL GEOGRAPHY

BY

DAVID PAGE, F.R.S.E. F.G.S.

AUTHOR OF 'INTRODUCTORY TEXT-BOOK OF PHYSICAL GEOGRAPHY,' 'INTRODUCTORY AND
ADVANCED TEXT-BOOKS OF GEOLOGY,' 'HANDBOOK OF GEOLOGICAL TERMS AND
GEOLOGY,' 'PAST AND PRESENT LIFE OF THE GLOBE,' ETC. ETC.

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P R E F A C E.

IN connection with his Text-Books of Geology, the Author has long meditated the production of two similar works on the closely-allied science of Physical Geography. The two subjects are most intimately connected—Geology forming, as it were, the groundwork of Geography, and Geography, on the other hand, becoming the field in which the operating causes of Geology are most obviously and intelligibly at work. The one becomes, in fact, the complement of the other; and the student of Geology can have no better preliminary training than a systematic course of Physical Geography; while the student of Geography cannot more readily ascend to the higher problems of his science than through the teachings of Geology. Though thus closely related, the two sciences may be studied, each on its own basis; and a large amount of knowledge may be acquired respecting the geographical conditions of the world—its lands, waters, and atmosphere; their mutual actions and reactions; the distribution of mineral, vegetable, and animal productions; and the bearings of these on the intellectual and social progress of man—without knowing more of Geology than merely being able to appreciate and apply its more obvious deductions.

Convinced of this, the Author has endeavoured to pro-

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It seems the student in the comprehension of his subject in exclusive necessity of Terms has been appended, and a number of illustrations inserted in the text: but the accompaniment of maps has been rendered unnecessary by the recent publication of several excellent Atlases of Physical Geography, and, above all, by those constructed by Mr Keith Johnston, and issued at very moderate prices by the publishers of the present treatise.

ASPHALTUM PLANK, SHINGLES,
NINE LBS.

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PHYSICAL GEOGRAPHY.

I.

INTRODUCTORY OUTLINE.

Aim and Objects of the Science.

1. GEOGRAPHY (from two Greek words, *ge*, the earth, and *graphie*, a writing or description) embraces, in its widest sense, all that can be known of the superficial aspects of our globe—its lands and waters, their extent and configuration, their altitude and depth, the atmosphere that surrounds them, their varied conditions and climate, and, finally, the distribution of the plants and animals by which they are respectively peopled. As Geology labours to interpret the rocky structure of the earth, and to write the history of the various mutations that structure may have undergone; so Geography endeavours to describe its external conditions, and to explain the causes by which these conditions are produced, and the purposes for which they are apparently maintained.

2. A science embracing so wide and varied a subject will readily present itself under several heads or departments; and thus we may have what is termed *Mathematical Geography*, which devotes itself to the size, form, motions, and general divisions of the earth as a planet, forming part of the solar system; *Political Geography*, which relates to the arbitrary subdivisions of the earth into empires, kingdoms, and states, with their populations, manners, religion, laws, industry, commerce, and other features distinctive of such subdivisions; *Descriptive* or *General Geography*, which restricts itself to a mere account of the external aspects of the lands and

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except the absence of those principles, of those ideas, of those general results, by which well-constituted minds are nurtured?"

4. Rising to this conception of his science, and viewing the beautiful and diversified field before him, the student of Geography meets a problem in every phenomenon that presents itself, and finds a solution in every incident that occurs. Why, for instance, do two countries, lying within the same parallels of latitude, present such differences in climate? Why are mountain-heights perpetually enveloped in snow, while the lower ridges are clothed in verdure and blossom? Why does one region of a continent be arid and rainless, while another is deluged with periodical torrents? Why do the winds in certain latitudes blow steadily and for weeks in one direction, while in another they are fitful and irregular? Why should one expanse of ocean be still and tideless, while another swells and falls with tides, and is traversed by currents? Why should the plants and animals that flourish in one region, dwarf and die out if transferred to another that seems equally fertile in soil and genial in climate? Why should the men at the mountain foot be tillers of fields and dressers of vineyards, while those a thousand feet higher are herdsmen and shepherds? Or why should one country be the scene of busy industry and successful commerce, of intellectual activity and mental culture, while another, as fair and even more fertile, remains the mere squatting-grounds of indolent, dependent, and semi-civilised hordes? These and a thousand similar questions press themselves upon the attention of every geographical observer; and while the facts may be detailed with clearness and accuracy by Descriptive Geography, to Physical Geography, in particular, we must turn for a rational solution of the phenomena presented.

5. In the prosecution of his subject the student of Physical Geography appeals to Astronomy for what relates to the figure, size, motions, and other primary conditions of our planet; to Geology for the structure and constitution of the rocky crust, which forms, as it were, the groundwork of all Geography; to Cosmology for much that belongs to climate and its allied phenomena; while from Chemistry and Physiology he derives important aid in dealing with the nature, growth, and dispersion of plants and animals. There, for example, is an island in the ocean: what is its position on the earth's surface—that is, its longitude; when will its sun rise and set, compared with London; what are the limits of its seasons; what is the force of gravity at its surface; what is the direction and rate of its oceanic circulation; what is the direction and rate of its atmospheric circulation; what is the direction and rate of its magnetic circulation? and many other questions. These, strictly speaking, belong to Astro-

nomY and Mathematics; but the geographer, availing himself of their aid, appeals to them for the solution of these problems. Again, the island is rocky and precipitous towards the north and west, while towards the south and east it falls away in gentle slopes and terraces. The north-western section presents, in the main, a series of basaltic crags and rocky hill-tops, while the south-eastern consists of clays and loams that lie on upturned strata of sandstones, limestones, and shales. There is a small circular lake or tarn up among the hills, while along the junction of the sandstones and basalt numerous springs rise and find their way to the low lands below. This is the structure of the island, and Geology endeavours to explain it. Further, while the hill-tops are often enveloped in mists, the lower slopes rejoice in sunshine; and not unfrequently, when the heights are covered with snow, the low grounds are fresh and open. The rainfall on the western coast is several inches more than that on the east; and the north-east winds are cold and parching, while the south-west are warm and laden with moisture. This is its Climatology, and Meteorology lends her aid to an explanation of these opposing phenomena. Still further, the plants that flourish on the basaltic crags are never found on the clayey slopes below; while even on the slopes and terraces different plants affect different soils, though exposed to the same sunshine and moisture. Chemistry and Physiology resolve these problems; and Physical Geography, while it describes and accounts for the whole, must own her obligations to these and other allied departments of natural science. Though drawing, however, in this manner from other sciences, it by no means follows that the student should be deeply read in Astronomy, Geology, or Meteorology. All that is necessary is, that he be able to perceive the connection and interbearings of these sciences, and be capable of appreciating the importance of their deductions in as far as they relate to his own immediate study of Physical Geography.

Theoretical and Practical Bearings.

6. The value of such a science must be obvious to the most casual observer. To determine the relative extent of the land and water that constitute this terraqueous surface—the varying altitudes of the one and the depths of the other, the climates of the one and the winds and currents that traverse the other, with the infinitely diversified mineral, vegetable, and animal productions of both—is not only a source of high intellectual enjoyment

and culture, but a task of prime industrial necessity. This globe is the sole scene of man's earthly labours—his cradle, the theatre of his life-actions, his grave! Scattered over its surface, separated by sea and mountain, enjoying different climates, and placed in proximity to different mineral, vegetable, and animal products, it is a natural necessity that different nations should trade and barter with each other. To ascertain the peculiarities of this varied surface, to learn the variety of its products—to know all, in fine, that relates to the home we tenant, and the comforts and necessities with which it is furnished, as well as the obstacles or facilities that lie in the way of obtaining them—is the sum and substance of Geography. The observation and reasoning required in geographical research, the amount of information obtained, and the curiosity gratified by faithful descriptions of distant and diverse regions, constitute, on the one hand, its theoretical value; acquaintance with their mineral, vegetable, and animal products, now so indispensable to civilised existence, the conditions under which these occur, and the capability of the latter for naturalisation in other countries, form, on the other hand, its economical or practical importance.

7. To the navigator dependent on the winds and currents of the ocean, what more necessary than a knowledge of the times, directions, and limits of these aerial and aqueous movements? The determination of shoals and sandbanks, of sunken rocks and reefs, is no doubt highly valuable; but it is a higher effort of philosophy to determine the causes and courses of these wind and water currents—to teach the sailor how to shun the storms of the one, and to cast himself on the favouring stream of the other. To the pioneer and settler in new lands, what more important than a knowledge of the climate, the seasons, and the products of his adopted home? or what more valuable than the teachings of Physical Geography to the merchant-traveller in search of new objects of enterprise and sources of wealth? To the botanist and zoologist, who deal with the strictly scientific aspects of natural history, as well as to the gardener and farmer, who seek to naturalise the plants and animals of different regions, there is no science whose bearings are so immediate as that which reveals the geographical distribution of life, and the causes that determine the order of that distribution. To the physiologist and psychologist who would study the influence of climate and other external conditions on health as well as on mental character; and to the political economist and statesman who have to deal with the peculiarities of different nations and the products of their countries, Physical Geography becomes a science of direct and important

interest. Combining, therefore, its theoretical with its practical bearings, our science has paramount claims alike on the attention of the philosopher, the statesman, the sailor, the farmer, the merchant, and manufacturer.

8. To present an outline of this science in its higher bearings is the object of the present treatise; and the student will best accomplish his purpose who step by step confirms the statements of the text by reference to the maps of his Atlas. By this double process any little difficulty will be more readily mastered, while the facts will be fixed more clearly and permanently on the memory. Every principle, thoroughly understood, becomes a key to some other problem; hence the value of systematic treatment, and the necessity of a clear comprehension of the successive stages by which the higher problems are attained. The study of General Geography—the positions of towns, courses of rivers, heights of mountains, and the like—is for the most part little better than a task of memory; Physical Geography, on the other hand, requires reasoning at every step, and the student will find his reasonings greatly assisted not only by the systematic use of his Atlas, but by the habit of appealing to the phenomena presented by his own immediate district. There are few localities, however limited, that do not present their alternations of hill and dale, of lake and river, of warm winds and cold winds, of periods of drought and periods of rainfall, of plants that love the marsh and others that thrive only in the thirsty upland; and by noting such distinctions, and the causes concerned in their production, the mind by such training will be better prepared for the comprehension of the phenomena of wider and more varied regions. As the botanist, zoologist, and geologist find the objects of their studies in every walk through the fields around them, so the student of Physical Geography will find the illustrations of his science in every locality he may visit. Every district has its own features of high-land and low-land, its streams and lakes and rivers, its peculiar winds and rains and frosts, its special arrangements of plants and animals; and he who understands best the governing causes of these local peculiarities will be best able to deal with the general problems of Physical Geography. There is nothing fortuitous in the economy of our planet: every breeze that blows, every cloud that sweeps across the firmament, and every shower that falls—fickle, uncertain, and local as these may appear—are as much the results of law and law-directed forces as the rising and falling of the tides or the revolutions of the planets. Impressed with this conviction, and seeing how closely every incident in nature is connected with another, the student will consider no occurrence as too trivial,

and no fact as too insignificant, to deserve his attention. Impressed with this conviction, the most fitful and uncertain phenomena assume the character of regularity and order, and the determination of the law of their recurrence becomes a hopeful and exhilarating pursuit.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding paragraphs we have endeavoured to show that the object of Physical Geography is to describe the external conditions of the globe, and discover the causes by which they are maintained or modified. It treats of the earth's surface as composed of land and water, determines their extent and configuration, their altitude and depth, the climate and other conditions that influence the growth and distribution of the plants and animals by which they are respectively peopled, and, rising above these, endeavours to account for the mental and social peculiarities of different nations as seemingly dependent on external phenomena. Deriving from Astronomy what relates to the figure, dimensions, motions, and other primary features of our planet; from Geology the structure and composition of its rocky crust; from Meteorology the proximate causes of the diversity of climates; and from Chemistry and Physiology the more intimate nature of vegetable and animal life,—Physical Geography proceeds to apply these adjuncts to its own proper field of inquiry, and from the whole deduces a rational and connected account of the cosmical phenomena by which we are surrounded. "Its ultimate aim," in the words of the immortal Humboldt, "is to recognise unity in the vast diversity of phenomena, and by the exercise of thought and the combination of observations, to discern the constancy of phenomena in the midst of apparent changes." As a science of observation and deduction in connection with the external conditions of the beautiful planet we inhabit, it possesses high intellectual attractions; and as bearing on its mineral, vegetable, and animal products—their abundance, distribution, and capabilities of dispersion—it becomes to civilised nations a study of prime industrial importance.

II.

THE EARTH—ITS GENERAL OR PLANETARY RELATIONS.

Figure, Motions, Dimensions.

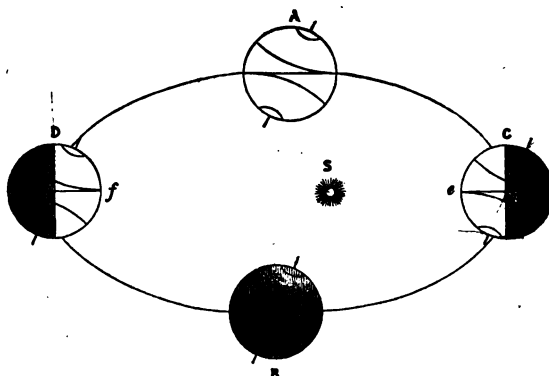
9. By the general relations of the earth are meant those primary conditions of form, size, density, motion, and the like, which belong to it as a member of the planetary system. From these conditions arise all those multifarious actions and reactions that take place on its surface—the alternations of night and day, heat and cold, summer and winter, growth and decay, the winds and motions of the atmosphere, the tides and currents of the ocean, and, in fact, all that confers on it geographical diversity and change. Thus, on its axial rotation depends the recurrence of light and darkness; from its revolution round the sun arises the succession of the seasons, with all their varied effects on vegetable and animal life; from the unequal reception of the sun's heat by the terraqueous surface and atmosphere result the multifarious phenomena of what we call weather and climate; while from the attraction of the sun and moon, and the earth's own proper motions, spring the flow and ebb of the tides, and the other great currents of the ocean. The consideration of these conditions belongs, no doubt, more especially to Astronomy and Physics, but as much may be here recapitulated as will enable the student to lay the foundation, as it were, of his own special science.

10. The province of Physical Geography is not merely to observe and describe, but to explain and determine. Here is a globe revolving and rotating in obedience to the laws of gravitation and attraction; and as motion is inseparably associated with change—change of place or change of condition—the nature of these changes, and the secondary results arising therefrom, constitute the legitimate themes of our science. Manifested on or near the accessible surface, these phenomena become apparent to every observer; but the producing causes are often so complicated by action and reaction on each other, that without a knowledge of the general

relations of the earth, it would be impossible to arrive at a satisfactory determination. As there is no independent existence in nature, so it is necessary to have some idea of the whole; and as our planet is but one of a brotherhood, it is necessary to the comprehension of its individual constitution to have some notion of the relations that subsist between the fraternity. It is for this reason that Geography appeals to Astronomy for a knowledge of the planetary conditions of the earth, in as far, at least, as these appear to bear on its superficial phenomena.

11. Astronomers have determined that the earth we inhabit is one of a number of planets that revolve, at different distances and with different velocities, round the sun as a common centre, constituting what is termed the *Solar System* (Lat. *sol*, the sun). These bodies—some of which are nearer the sun than our earth, and others more remote, some vastly larger, and others smaller—are nearly all spherical in form, and move from west to east, in courses or *orbits* more or less circular. The distance of the earth from its central orb is 95,173,000 miles, or, in round numbers, ninety-five millions of miles. Its time of revolution round the sun is about $365\frac{1}{4}$ days—or, more precisely, 365 days, 5 hours, 48 minutes, and 50 seconds—and this period of revolution we designate a *year*. Besides this annual revolution round the sun, the earth rotates or turns on its own axis in 24 hours, or, more exactly, in 23 hours, 56 minutes, and 4 seconds—and this period of rotation constitutes a *day*. In other words, the earth rotates three hundred and sixty-five times during the course of a single revolution; and thus the more frequent and obvious motion of daily rotation has been taken as the unit of measurement for the larger and less apparent. In these movements of annual revolution and daily rotation, the earth, like several other of the primary planets, is attended by a minor or secondary body, which revolves round her as she round the great central luminary of the system. This secondary planet or *satellite* (Lat. *satelles*, an attendant) is the Moon, which is 2160 miles in diameter, and which completes her revolution round her parent orb (at a distance of 24,000 miles) in 27 days, 8 hours—or, in round numbers, in 28 days, or one lunar *month*. These motions and times of motion are determined and influenced by the attraction and gravitation of the sun and other planets; and it is by the same great forces that all the heavenly bodies that lie beyond our system are held in harmonious order, and, in all likelihood, in analogous fraternities. As the secondary planets revolve round their primaries, and these, again, round the sun, so the solar system itself may revolve round some vaster centre, and this order of things through systems and centres that baffle the grasp of our finite conceptions.

state. When the point presented to the sun is at *e* (which is on the 22d December), it is midsummer to all the southern parts of the earth, and winter to all the north; but as the exposed part advances towards the point *f*, the northern regions gradually re-



The Seasons.

ceive more and more heat, till, on the 21st of June, it becomes their midsummer. Having glanced at the main systematic motions of the earth that regulate our days, years, months, and seasons, we shall now advert to her own proper dimensions, as determined by the astronomer and mathematician.

13. The body which thus rotates on its own axis while it revolves round the sun, and is in turn revolved around by the moon, is not, strictly speaking, a sphere or globe, but a *spheroid* (Gr. *sphaira*, a globe; *eidos*, likeness), or body of a sphere-like form. A diameter taken along its axis, or the ideal line round which it rotates, is only 7899.170 miles, while one taken in the opposite direction is 7925.648 miles. The one diameter thus exceeds the other by about 26½ miles, thereby causing a deviation from the true globular form, and producing what mathematicians term an *oblate spheroid*—that is, a figure flattened in the direction of its axis, and bulging out all around somewhat in the shape of an orange. Such a figure can be readily produced by rapidly spinning a ball of yielding material (like soft clay or putty) round its own axis, when the tendency which all revolving bodies have to fly off from the centre (centrifugal force) causes the mass to bulge out at the rotating circumference and to flatten in proportion at either end of the axis. To this centrifugal force arising from rotation, and to some original yielding condition of the

and the circumference as 25,000 miles. The superficial area of a globe of these dimensions amounts to 197 millions of square miles; and of these about 51 millions consist of land, and 146 millions are occupied by water. The proportion of land to that of water may, therefore, be said to be, in round numbers, as *one to three*; or, in other words, while one-fourth of the earth's surface consists of dry land, the other three-fourths are covered by the waters of the ocean. This is not the place to inquire into the causes of this unequal distribution, or the purposes it was meant to subserve; but we may rest assured that it is the result of Design, and in necessary harmony with the higher and vital ordinances of nature. The *solid contents* of the mass have, in like manner, been computed to exceed 260 thousand millions of cubic miles—an amount which, though expressible in figures, is altogether beyond the grasp of human conception. It is enough, then, for the student to be convinced of the magnitudes of such amounts, without troubling himself with the remembrance of their numerical expressions.

[Though impossible to grasp the conception of the numerical amounts, we may here, for the sake of comparison, exhibit in tabular arrangement the diameters, solid contents, volumes, weight, and specific gravities of the several members of the solar system, as calculated by the astronomer and physicist:—

	Diameters in English Miles.	Solid Contents in Millions of Cubic Miles.	Volume, Earth being=1.	Weight, Earth=1.	Force of Gravity at Earth=1.	Specific Gravity, Earth=1.
Vulcan, . .	785	.....	.....	.....	.....	.....
Mercury, . .	3,140	10,195	0.06	0.18	1.15	2.94
Venus, . .	7,700	233,521	0.96	0.90	0.91	0.92
Earth, . .	7,916	260,775	1.00	1.00	1.00	1.00
Mars, . .	4,100	48,723	0.14	0.15	0.50	0.95
Planetoids, . .	.....	.....	.....	.....	0.05	.....
Jupiter, . .	90,000	343,125,820	1,414.20	333.61	2.45	0.24
Saturn, . .	76,068	245,089,877	734.80	101.78	1.00	0.14
Uranus, . .	34,500	19,737,774	82.00	19.93	1.15	0.24
Neptune, . .	42,000	.....	150.00	31.79	1.20	0.23
Sun, . .	883,000	390,830,020,687	1,407,124.00	357,000.00	27.90	0.25
Moon, . .	2,160	5,374	0.02	.0125	0.16	0.62

atmosphere.

with the materials at
considerable precision. The
of the most recent rocks is about $2\frac{1}{2}$
° Fahrenheit, while the

earth's mass, is its oblate or spheroidal form usually ascribed. The earth's mass, as is well known, is kept together by the force of *gravitation*; and had it remained at rest, its form would have been perfectly spherical; but the moment it began to turn on its own axis, the particles of its mass began to obey another law—viz. that of *centrifugal force*, which exerts itself at right angles to the axis of rotation, and in proportion to the distance from that axis. Hence the greater bulging out of the earth's mass at the equator, where the distance from the axis is greatest; and hence also the gradual declension of centrifugal force as we proceed towards the poles. Gravitation and centrifugal force are thus the two counteracting powers by which the earth is sustained in its present spheroidal form; and any variation in its dimensions, density, or velocity of rotation, would be accompanied by a proportionate deviation from its existing form.

[It has been proved, we have said, by the astronomer and mathematician, that the true figure of the earth is that of an *oblate spheroid* of revolution; but of its *general spheroidal* or *globular form*, an ordinary observer has many proofs, among which may be mentioned the following:—1. As a vessel sails away from the land, we first lose her hull, next of her lower or main sails, and lastly of her topmost pennants, thus clearly showing that she is passing over a convex or bulging surface. 2. The reverse of this also holds true; for the vessel, as she approaches the land, first sees the mountain-tops, and on getting nearer it, the lower grounds stage by stage make their appearance. Had the earth's surface been flat, it would have been all at once revealed by the rays of the sun; but being convex or round, each place turns from west to east, has its sunrise, noon, sunset, and night in succession—one half of the globe being thus always in light while the other is in darkness. 3. In traveling any considerable distance, either north or south, new stars gradually come into view in the direction to which the traveler is advancing, while others disappear in the direction to which he is receding. 4. Many navigators, by constantly sailing in a direct line, or nearly so, whether due east or due west, have returned to the port from which they set out, thus making what is termed the *circles of the globe*. 5. In consequence of the round form of the earth, the dip or depression of the horizon is about 8 inches per mile, and account engineers in cutting canals have to make an allowance for this extent in order to keep the water at a uniform level. 6. The shadow which the earth casts on the moon is always circular. And, lastly, the earth being a globe, the other members of which are globes, it is evident that the sun is of the same form.]

To determine the dimensions given to the earth, the diameter of the earth is measured at the equator, and the result is found to be 7927 miles.

and the circumference as 25,000 miles. The superficial area of a globe of these dimensions amounts to 197 millions of square miles; and of these about 51 millions consist of land, and 146 millions are occupied by water. The proportion of land to that of water may, therefore, be said to be, in round numbers, as *one to three*; or, in other words, while one-fourth of the earth's surface consists of dry land, the other three-fourths are covered by the waters of the ocean. This is not the place to inquire into the causes of this unequal distribution, or the purposes it was meant to subserve; but we may rest assured that it is the result of Design, and in necessary harmony with the higher and vital ordinances of nature. The *solid contents* of the mass have, in like manner, been computed to exceed 260 thousand millions of cubic miles—an amount which, though expressible in figures, is altogether beyond the grasp of human conception. It is enough, then, for the student to be convinced of the magnitudes of such amounts, without troubling himself with the remembrance of their numerical expressions.

[Though impossible to grasp the conception of the numerical amounts, we may here, for the sake of comparison, exhibit in tabular arrangement the diameters, solid contents, volumes, weight, and specific gravities of the several members of the solar system, as calculated by the astronomer and physicist:—

	Diameters in English Miles.	Solid Contents in Millions of Cubic Miles.	Volume, Earth being = 1.	Weight, Earth = 1.	Force of Gravity at Earth = 1.	Specific Gravity, Earth = 1.
Vulcan. .	785	....	....	....	....	....
Mercury. .	3,140	10,195	0.06	0.18	1.15	2.94
Venus. . .	7,700	223,521	0.96	0.90	0.91	0.92
Earth. . .	7,916	260,775	1.00	1.00	1.00	1.00
Mars. . .	4,100	48,723	0.14	0.15	0.50	0.95
Planetoids,					0.05	....
Jupiter. .	90,000	843,125,820	1,414.20	333.61	2.45	0.24
Saturn. . .	76,063	245,089,877	734.80	101.78	1.00	0.14
Uranus. . .	34,500	19,727,774	82.00	19.98	1.15	0.24
Neptune. .	42,000	.....	150.00	31.79	1.20	0.23
Sun. . .	883,000	399,839,629,687	1,407,124.00	357,000.00	27.90	0.25
Moon. . .	2,160	5,274	0.02	.0125	0.16	0.62

Density, Temperature, Atmosphere.

15. The density of the globe, as compared with the materials at its surface, has been determined with considerable precision. The average or mean density of the most prevalent rocks is about $2\frac{1}{2}$ times that of water at the temperature of 62° Fahrenheit, while the

density of the whole mass, as determined by astronomical experiment, is $5\frac{1}{2}$ times 5.675 that of water. It is evident from this that the interior of the earth cannot be composed of the same materials that constitute its outer portion: for these, under the law of gravitation, would be so compressed at the depth of a few miles as to give a greater mean density to the whole mass than its astronomical relations allow. Thus it has been calculated that air, at the depth of 54 miles from the surface, would become as heavy as water; that water, at the depth of 362 miles, would be as dense as quicksilver; and that the density of marble at the centre of the earth would be 119 times greater than what it is at the surface. Hence, then, the interior of the earth is composed of materials differing in density in nature from those known at its surface, or the compression of gravitation must be counteracted by some highly expansive force, such as heat, so as to maintain the mean density which astronomy and physics have determined. It is thus that geologists and geographers adopting the language of geologists, speak of the "crust of the globe," and of the "interior of the globe"—meaning by the former that outer portion composed of rocks and rock-masses, which can be observed and examined; and by the latter that inner portion which is placed beyond such investigation, and respecting which we can infer little more than a conjecture and hypothesis.

It is closely connected with the density of the globe is its temperature, or the amount of heat that pervades it. As one of the laws of the solar system, the earth has a variable superficial, or atmospheric temperature: it has also a temperature peculiar to the rocky crust; and, arising from volcanic action, there is also a higher and more remarkable interior or central temperature. Respecting the *atmospheric temperature*, which constitutes the great theme of climatology, to be noticed hereafter (Chap. XII.), it may be said, in the mean time, that it is influenced from day to day, and from season to season, by the heat of the sun: that it varies according to the latitude, being greatest at the equator, and gradually decreasing towards the poles: that it is greatly modified by the extent and distribution of sea and land—the sea and sea-coasts being more equable than inland continents, which experience extremes of heat in summer, and extremes of cold during winter; that it is also modified by the absorbent or radiating nature of the soil, according as this is dark or light-coloured, dry or moist, porous or solid. Lastly, that it is notably affected by elevation above the level of the sea—the higher being the colder regions.

On the opposite coast, on the other hand, direct heat of the sun, butre, as radiated

from the moon, by heat generated chemically among its own materials, or by heat derived by conduction from the interior. During summer, for instance, the earth is warmed to a certain depth by the heat of the sun; during winter this heat is given off to the surrounding atmosphere; and though the heat of one summer and the cold of one winter may differ from the heat and cold of others, still, on an average of seasons, the results are pretty equable. It may, therefore, be stated in general terms, that in summer the crust of the earth, at small depths, is colder than at the surface; that during winter the crust at these depths is warmer than at the surface; but that, at the depth of 80 or 90 feet, the variations of summer and winter become wholly insensible. As to the amount of heat generated within the crust by chemical, electrical, and magnetic forces, we have no accurate knowledge; but to these forces, as well as to conduction from the interior, may safely be ascribed the higher temperatures experienced in mines, wells, and other deep-seated situations.

18. Respecting the *heat of the interior*, we see it abundantly manifested in hot springs, volcanoes, and the like; and have by direct experiment been enabled to arrive at some important facts relative to its descending rate of increase. Thus it has been found by experiments in coal-pits, Artesian wells, and metalliferous mines, that, after passing the depth at which the surface-heat is inappreciable, the temperature begins to rise, and this gradually and steadily for every fathom of subsequent descent. Reckoning this "stratum of invariable temperature" at from 60 to 90 feet below the surface, according to the nature of the soils and rocks passed through, a rise of 1 degree of Fahrenheit takes place for every 60 feet of further descent; and calculating at this rate of increase, a temperature (2400° Fahr.) would be reached, at a depth of 25 miles or thereby, sufficient to keep in fusion such rocks as basalt, greenstone, and porphyry. At the same rate of increase, or even admitting, as some contend, that the thermometer only rises 1 degree for every 90 feet of descent, we would, at the depth of 150 miles or thereby, arrive at such a temperature that even the most refractory rock-substances would be dispersed before it like vapour. We know little, however, of the deportment of heat under such a pressure as must exist at these depths, and can only indicate the line of reasoning that leads to the general belief that the solid or rocky crust forms but a comparatively thin film, and that the great interior mass exists in a state of high incandescence or molten fluidity. Intense as this interior heat may be, and active as it undoubtedly is in the production of volcanic phenomena, the surface temperature of the globe is scarcely, if at all, affected by

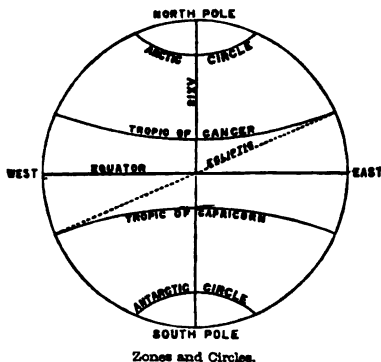
At the

Technical Subdivisions—Points, Circles, Zones, &c.

20. In treating of the earth thus constituted and surrounded, geographers make use of certain terms and technicalities expressive of distance, position, and the like, on its surface, and with these it will be necessary for the student, at this stage, to render himself familiar. Thus, the direction from which the earth moves in its daily rotation is called the *West*; that towards which it moves, the *East*; the point to which a spectator looks, with the east on his right hand and the west on his left, is called the *North*; and that behind him the *South*. In this rotation from west to east, any point on the earth's surface turns towards the sun in the morning, and away from him after mid-day; and thus the terms *Sunrise* and *Sunset* (the sun being a stationary centre) express not real, but merely apparent phenomena. The imaginary line on which the earth rotates is termed its *Axis*, and the terminations of this axis its *Poles*—that towards the north being known as the *North Pole*, and that towards the south the *South Pole*. From an idea of the early geographers, who were inhabitants of the northern hemisphere, that the north pole was uppermost (though in reality there can be neither upper nor under in a globe freely rotating in space), it is customary in our maps and charts to place the northern part at the top, and the southern at the bottom, with the east on the right hand and the west on the left. A line distant alike from either pole, and dividing the earth into two equal portions (Lat. *æquus*, equal), is called the *Equator*; the northern half being known as the *Northern Hemisphere*, and the southern as the *Southern Hemisphere*. In the same way we may speak of the *Eastern Hemisphere* and *Western Hemisphere*, by supposing the globe divided by a line passing through the poles, and thus necessarily cutting the equator at right angles. Reckoning London as a fixed point on such a line, Europe, Asia, and Africa will lie in the eastern hemisphere, and North and South America in the western. (Map, page 49.)

21. Like other circles, the circumference of the earth is divisible into 360 equal parts or *degrees*, and in this case each degree will equal about 69.05 British statute miles. At the distance of $23\frac{1}{2}$ degrees north and south of the equator, as shown in the accompanying diagram, are two parallel lines called the *Tropics* (Gr. *tropē*, a turning), from their marking the turning-points of the sun in the ecliptic; that on the north being known as the *Tropic of Cancer*, and that on the south as the *Tropic of Capricorn*, because these constellations occupy a corresponding part in the heavens. At the same distance ($23\frac{1}{2}$ degrees) from either pole is a

parallel line—that on the north being called the *Arctic Circle* (from the northern constellation, *Arctos*, the Bear), and that on the south the *Antarctic Circle*, because opposite (*anti*, opposite) to that of the north. The space or belt between the tropics is



called the *Torrid Zone*, because the sun, being always vertical in some part of that space, produces a greater degree of heat than in regions where his rays strike more obliquely. The spaces between the tropics and the Arctic and Antarctic Circles, on either side, are termed the *Temperate Zones* (north and south); and those between these cir-

cles and their respective poles the *Frigid Zones*. The breadth of each of the torrid zones is therefore about 1622½ statute miles; * of each of the temperate, about 2969; and of each of the frigid, 1622½ miles. Or, calculating their areas in square miles, the earth's superficies is made up nearly as follows:—

North Frigid Zone, . . .	8,132,797 square miles.
North Temperate Zone, . .	51,041,592 "
Torrid Zone, . . .	78,314,115 "
South Temperate Zone, . .	51,041,592 "
South Frigid Zone, . . .	8,132,797 "

It is customary for the botanist and zoologist to subdivide those zones more minutely into equatorial, tropical, sub-tropical, warm-temperate, cold-temperate, sub-arctic, arctic, and polar; but of these subdivisions and their characters when we come to treat of the distribution of vegetable and animal life.

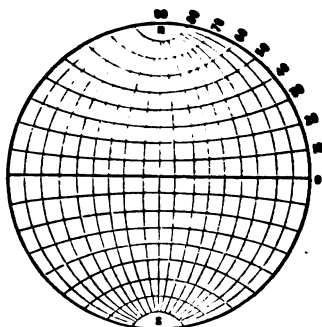
22. The equator has been already described as a circle exactly between the poles, and cutting the globe into two equal portions. A line which cuts the equator obliquely, and touching upon opposite sides of the tropics, is called the *Ecliptic* (Gr. *ekleipsis*, an eclipse). The ecliptic is the orbit described apparently by the sun round the earth, but in reality by the earth round the sun, and is named from the circumstance that all eclipses can happen only when the

* The length of a British statute mile is 1760 yards, or 5280 feet; while a geographical mile is 2028.92 yards, or 6086.76 feet.

moon is on the same plane, or very near it. The points where the ecliptic cuts the equator are called the *Equinoctial Points* or *Nodes*, because when the sun is in these parts of his course, the day and night are of equal duration. These equinoxes take place twice a-year—namely, on the 21st March and 21st September. The term *Greater Circles* is sometimes applied to the equator and ecliptic, because they encircle the earth at the thickest part, or form planes that pass through its centre; and that of *Lesser Circles* to the tropics, arctic and antarctic circles above described. Besides these circles, another set of lines, drawn from pole to pole over the earth's surface, and cutting the equator at right angles, are termed *Meridians* (Lat. *meridies*, mid-day), because when any of these lines is opposite the sun it is mid-day, or twelve o'clock, with all the places situated along that meridian on the same side of the globe, while on the other side it is midnight. When it is noon, for instance, in any particular part of Britain, it is midnight at an opposite and corresponding point near New Zealand, and so on for the intermediate hours at directly opposite parts along the same meridian. Thus, diametrically opposite points on the globe are said to be the *Antipodes* of each other (Gr. *anti*, opposite, and *pous*, *podos*, foot), because the feet of their inhabitants are placed, as it were, in opposition to each other.

23. The position of a place on the earth's surface is determined by what is termed its *Latitude* and *Longitude*. The latitude of a place is its distance north or south from the equator; hence we speak of north latitude (N. Lat.) in the northern hemisphere, and of south latitude (S. Lat.) in the southern hemisphere. Longitude, on the other hand, is measured east and west of any fixed meridian—different countries adopting different meridians (usually that of their capitals), and Britain that of the Royal Observatory at Greenwich; hence English geographers speak of east longitude (E. Long.) and west longitude (W. Long.), according as a place may be situated eastward or westward of the meridian of Greenwich. The terms *longitude* and *latitude* arose from a notion of the ancients that the earth was longer from east to west than from north to south; in other words, that it had *length* (longitudo) and *breadth* (latitudo)—an idea which is thereby most conveniently expressed. The circles on the earth being divided into 360 degrees, and each degree again into 60 minutes, each minute into 60 seconds, and so on, the position of a place can be indicated with great precision; and for the sake of brevity certain signs are employed, as $4^{\circ} 6' 12''$, meaning thereby 4 degrees, 6 minutes, and 12 seconds. The distance between the equator and either pole

being only the fourth part of the earth's circumference, the latitude of a place north or south of the equator can never exceed the fourth part of 360, or 90 degrees. Longitude, on the other hand, being measured east and west of a fixed meridian, embraces a



Parallels and Meridians.

whole hemisphere, or 180 degrees; and as the meridians all converge towards the poles, the degrees of longitude become less and less as we approach these extremities. The lines of latitude being necessarily parallel to each other, geographers speak of *parallels of latitude*, designating those that lie near to the equator as *low* latitudes, those that approach the poles as *high* latitudes, and those that intervene as *middle* latitudes.

[It has been stated above that the value of a degree of longitude varies according to the latitude, being equal to a degree of latitude at the equator, but gradually becoming less as we approach the poles. The following table exhibits this diminution for every 5 degrees of latitude both in geographical and British statute miles:—

Degree of Latitude.	Geographical Miles.	English Miles.	Degree of Latitude.	Geographical Miles.	English Miles.
0	60.00	69.07	50	33.57	44.35
5	59.77	68.81	55	34.41	39.58
10	59.09	67.95	60	30.00	34.50
15	57.95	66.65	65	25.36	29.15
20	56.38	64.84	70	20.52	23.60
25	54.38	62.53	75	15.53	17.86
30	51.96	59.75	80	10.42	11.98
35	49.15	56.51	85	5.23	6.00
40	45.96	52.85	90	0.00	0.00
45	42.43	48.78			

NOTE, SUPPLEMENTARY AND EXPLANATORY.

In the foregoing chapter we have noticed those primary conditions of climate, namely, day, cloudiness, temperature, and the like,

which belong to the earth as a member of the solar system. These conditions lie, as it were, at the foundation of all change and diversity on the earth's surface—day and night, heat and cold, summer and winter, meteorological fluctuation and climate, oceanic tides and currents, geological waste and reconstruction, and, in fine, all that confers diversity on land and water, and consequently on vegetable and animal life, being directly or remotely dependent on the original constitution of the globe, and its connection with the solar system. It is necessary, then, that the student should render himself familiar with the planetary relations of the earth—its spheroidal form, its daily and annual revolutions, its density, temperature, magnitude, and admeasurements, as well as with those terms and technicalities by which its several portions and positions are known and described. As an oblate spheroid, then, the earth has an equatorial diameter of 7925.648, and a polar diameter of 7899.170 miles (or, according to the mean of measured meridional arcs, 7926.05 and 7899.6), rotates on its own axis in 23 hours, 56 minutes, and 4 seconds, or in one *day*; revolves round the sun in an elliptical path or orbit in 365 days, 5 hours, 48 minutes, and 50 seconds, or one *year*; and is in turn attended by the moon, which performs her revolution in 27 days, 8 hours, or one lunar *month*. As the mean circumference of the earth is 24,858 miles, and as she rotates on her axis once in 24 hours, it is clear that any spot on the equator must be borne round at the rate of more than 1000 miles an hour. With every successive removal from the equator, however, the circles of latitude become smaller and smaller, and as they are all carried round within the same period of 24 hours, their rate of motion must be proportionally less. At the 60th parallel, for example, this motion is only 500 miles an hour, and at the absolute poles it ceases to exist. The mean density of the rocks known at the surface of the earth is about $2\frac{1}{2}$ times that of water, while that of the entire mass is $5\frac{1}{2}$, thereby showing that the interior consists of different material, or of materials in a different condition from those in its rocky crust. The earth's own proper temperature, as distinct from that received by its atmosphere and surface from the sun, increases according to the depth, and this increasing temperature is apparently the cause of volcanoes, hot springs, and other thermal phenomena. The increase being at the rate of 1 degree Fahr. for every 60 feet of descent or thereby, the deeper-seated portions must be in a state of high incandescence, or, at all events, in a condition very different from the solid rocks that constitute the outer crust; but these rocks being bad conductors of heat, the surface temperature, it is calculated, cannot be

surface of the material heat beyond the merest fraction of a degree. The earth is also surrounded by an aerial envelope or atmosphere, consisting in the main of 79 parts nitrogen and 21 parts oxygen, with a fractional percentage of carbonic acid; and this atmosphere is denser in the lower strata, is denser at the earth's surface, where it presses with a weight of 14½ lb. on the square inch, and becomes rarer and rarer as we ascend in space, till at the height of 50 or 60 miles its presence becomes inappreciable. This atmosphere is the medium through which the sun's light and heat are equally diffused: the laboratory in which all meteorological phenomena—winds, rains, clouds, storms, &c.—are elaborated, and in which the seasons whose varied mutations are the principal causes of all climatic diversity. In treating of the earth, such as terms and nomenclatures are necessarily employed by geographers, and with these the student should early render himself familiar. Thus the imaginary line on which the earth turns on her axis, running from west to east is termed the *axis*; the extremities of this axis north and south, the *poles*; the *equator*, the circle between the two poles which cuts the globe into two equal portions or *hemispheres*: the *torrid*, *temperate*, and *frigid* zones, the varying belts of surface temperature as we proceed northward and southward from the equator, where the sun's heat is greatest; the *meridian*, the apparent path of the sun round the earth; *meridians*, those lines drawn from pole to pole over the earth's surface, and at right angles to the equator, along which the sun is vertical at his highest daily ascension or *noon*; *latitude*, the distance of any place measured in degrees, north or south of the equator; and *longitude*, the distance of the same place east or west from any arbitrary or convenient meridian—that in Britain being the meridian of Greenwich; that in France, Paris; and that in Germany, the Faroe Islands.

To the student who wishes to enter more minutely into the consideration of the earth's planetary or astronomical relations, we may recommend perusal of Sir J. Herschel's 'Outlines of Astronomy,' Mr G. D. Chambers's 'Handbook of Descriptive and Practical Astronomy,' and Mrs Somerville's 'Connection of the Physical Sciences.' For a fuller explanation of the technical terms of this science, he may consult the *Glossary* appended to the pre-

III.

THE EARTH—ITS INDIVIDUAL STRUCTURE AND COMPOSITION.

The Rocky Crust—Its Constitution and Formation.

24. HAVING considered in the preceding chapter some of the more obvious relations of the globe as a member of the Solar system, and the terms usually employed to express their connections, we now proceed to describe the leading features of its own special structure. As the knowledge of its general relations was derived chiefly from Astronomy, so a knowledge of its individual structure is mainly obtained from the teachings of Geology. As the one set of facts could be taught without going deeply into the problems of the astronomer, so the other may be understood without entering largely into the reasonings of the geologist. What, for instance, is the nature of the earth's rocky crust? How are its rocks arranged, and how does this arrangement affect its superficial character? What has stretched out the level plain and upheaved the rugged mountain? What renders one soil obnoxious and sterile, and another genial and fertile? And as the earth's crust is continually undergoing modification under the operations of external and internal forces, what the effects of such modifications on the general geography of the globe? These and similar problems geology endeavours to solve, and, with a little explanation, these solutions may be rendered intelligible to the student of Physical Geography.

25. Geologists speak of the "crust of the globe" just as the housewife talks of the "crust of her loaf." The crust of the loaf is one thing, the inside of it another. The crust or exterior portion of the earth, composed of rocks and rock-materials that can be seen and handled, is one thing; the interior, of which we can know nothing by direct observation, may be, and in all likelihood is, a very different thing. By observation and comparison we can determine a great many truths respecting the structure and composition of the one; respecting the other we can offer at best

little more than conjecture. This outer portion or rocky crust is the great theatre of all geographical phenomena—the foundation of the land and waters—the arena of climatic influences—the field of vital development; and, as such, it behoves the geographer to know something of its history and constitution. That history, as geology has taught us, is a long and varied one; that constitution, as bearing more immediately upon the problems of geography, we shall endeavour briefly to explain.

26. On the most cursory inspection of quarries, railway-cuttings, sea-cliffs, and ravines, the observer will find a great portion of the rocks arranged in layers, or lying one above another in beds or strata (Lat. *stratum*, spread out). These are said to be *stratified*, and generally consist of sandstones, clays, shales or consolidated muds, limestones, and other similar rocks. He will also find another set not spread out in layers, but rising, hard and massive, in no determinate arrangement. These are termed the *unstratified*, and consist of such rocks as the granites, greenstones, basalts, and lavas. How, he will naturally inquire, have two sets of rocks so dissimilar in character and arrangement been produced? And as we can only interpret nature's productions by a knowledge of nature's operations, we must seek for the answer to this question in what is now taking place around us. And first, if we turn to any lake, estuary, or bay of the ocean, we will find that the mud, sand, and gravel carried down by the rivers or washed from the cliffs by the waves and tides, are deposited and arranged along the bottom of these receptacles in layers or strata more or less horizontal, and in course of ages one above another, precisely like the shales and sandstones of the quarries and sea-cliffs. Here, then, we are entitled to infer that rocks arranged in layers or strata have been formed through and by the agency of water (Lat. *aqua*); that is, have been deposited as sediment (Lat. *sedere*, to settle down) in water, or brought together and assorted by the action of moving water; and hence they are termed *aqueous*, *sedimentary*, or *strati-*



A A A, Stratified; B B, Unstratified Rocks.

fied. If we turn, in the next place, to the volcano or burning mountain, we find that lava and other molten rock-matters are discharged from its crater; and these, when cooled and consolidated age after age, form mountain-masses, and fill up chasms and rents produced by earthquakes, precisely as the granites and green-

stones and basalts do among the stratified rocks with which they are associated. Here, again, we are entitled to infer that the greenstones, basalts, and other similar rocks are the products of fire (Lat. *ignis*, fire), and hence they are designated *igneous*, *eruptive*, or *unstratified*.

27. In the crust of the earth, then, we have two main sets of rocks—the stratified and the unstratified; the one formed through and by the agency of water, the other through and by the agency of fire. The former are chiefly the products of aqueous and atmospheric waste, the latter the products of igneous reconstruction; and between these two forces, the aqueous and igneous, the crust of the earth has ever been held in habitable equilibrium. Were the aqueous and atmospheric forces to operate uncontrolled, all the higher portions of the dry land would in the course of ages be worn down, and the whole reduced to a dreary uniformity of level; but, to prevent such a contingency, the volcanic forces are perpetually exerting themselves from below, and once more upheaving the crust into dry land and diversity of surface. What the frosts and rains and rivers are wearing and carrying from the higher lands is deposited in layers of mud, sand, and gravel in the lakes and estuaries below; and what is wasted from the sea-cliffs by waves and tides is borne along and distributed in the bays and other sheltered recesses of the ocean. These deposits, in course of time, become consolidated, by pressure and internal chemical changes, into shales and sandstones and conglomerates; and we can readily conceive the low, level, superficial aspect of a globe where this sedimentary process went on unchecked for ages. But the forces from within are as incessantly at work as the forces from without, and sooner or later (according to some law whose order is yet unknown) these strata are upheaved into dry land, with all that diversity of surface which seems inseparable from the efforts of the earthquake and volcano. The great design of creation seems clearly to be diversity in time as well as diversity in space. Whether under the open air or under the waters of the ocean, hill and dale, level plain and rugged mountain, are ever attended by diversity of soil, diversity of winds and currents, heat and cold, and all the other climatic influences on which diversity of plant-life and diversity of animal life are so intimately dependent. To the primary geological oscillations of the earth's crust are we, therefore, indebted for all that confers on its surface geographical variety and diversity; and hence the value of some knowledge of geology to him who would thoroughly comprehend the existing aspects of nature.

Relative Age and Arrangement of Rock-Formations.

25. If, then, the crust of the globe be in a state of oscillation between the aqueous and atmospheric forces that waste and wear from without, and the igneous forces that reconstruct and upheave from within—if cliffs and hills are worn down, and lakes and estuaries filled up and converted into alluvial plains—if plains are thrown up into mountains, and the sea-bed into dry land—if large tracts of the earth are gradually raised higher and higher above the ocean, while other regions are gradually submerged—it is clear that different portions of the rocky crust must be of different ages, and composed of different materials. The present distribution of sea and land has undergone many noted modifications even within the historic era; and if such changes have been accomplished within a period so brief as a few thousand years, what may we believe to have taken place during the thousands of ages that preceded human history? So numerous have been these changes, as clearly demonstrated by geology, that every portion of the existing dry land has been repeatedly beneath the waters; and that which now constitutes the bed of the ocean, has in like manner been the dry land of former epochs.

"There rolls the deep where grew the tree;
Oh, Earth, what changes hast thou seen!
There, where the long street roars, has been
The stillness of the central sea.

The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mists, the solid lands—
Like clouds, they shape themselves and go!"

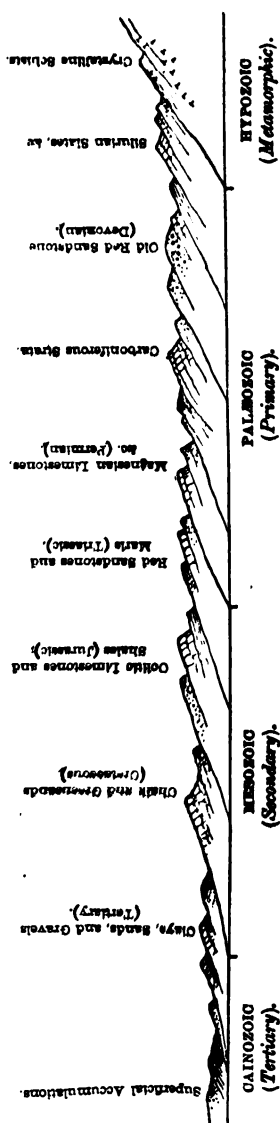
The record of these changes lies in the stratified rocks, each period producing its own sedimentary deposits, and these deposits constituting what geologists term a *formation*, as having been formed at a certain period, and under the peculiar conditions of that period. Farther, as the sediments of existing lakes and estuaries and seas imbed the remains of plants and animals that have lived in these areas, or have been drifted from the land—leaves, branches, trunks, bones, teeth, shells, and crusts; so the sediments of former ages contain the remains of plants and animals that then existed—these remains being petrified, or converted into stone. These petrifications, or *fossils*, as they are termed, differ widely in many instances from the plants and animals now peopling the globe; and this difference may be said to increase with the depth and age of the strata that contain them. As a general rule, the older strata

will be the deepest seated; the older, harder and more crystalline than the recent and superficial; and the older the strata, the greater will be the difference between their fossil plants and animals and the plants and animals now existing. Founding on principles such as these, geologists have arranged the stratified rocks into formations and systems according to their relative antiquities—each division representing (as nearly as can be determined) a different arrangement of sea and land, and a different aspect of vegetable and animal life during the period of its deposit.

29. Thus, beginning at the recent and superficial, which contain few extinct forms of life, and descending through systems whose fossils belong chiefly to extinct races, we have:—

<i>Systems.</i>	<i>Periods.</i>
1. POST-TERTIARY or RECENT ACCUMULATIONS.	} CAINOZOIC (Recent Life).
2. TERTIARY SYSTEM.	
3. CRETACEOUS or CHALK SYSTEM.	} MESOZOIC (Middle Life).
4. OOLITIC or JURASSIC SYSTEM.	
5. TRIASSIC or UPPER NEW RED SANDSTONE.	
6. PERMIAN or LOWER NEW RED SANDSTONE.	} PALÆOZOIC (Ancient Life).
7. CARBONIFEROUS SYSTEM.	
8. DEVONIAN or OLD RED SANDSTONE.	
9. SILURIAN and CAMBRIAN.	
10. METAMORPHIC or CRYSTALLINE STRATA.	} HYPOZOIC (Beneath Life).

Or, arranging them in diagrammatic form, as they occur in the British Islands, we have the intelligible representation that appears on the following page. It is not asserted that these rock-formations and systems occur in full and regular succession in every part of the world, but merely that such is their order in time wherever they have been examined by the geologist. The Old Red Sandstone or the Carboniferous system may occupy the whole surface of a country without any of the newer systems being present, just as the Chalk or Oolite may be the surface rock, without having the whole of the older strata below; but the oolite never occurs above the chalk, nor the old red sandstone above the coal. The order of their succession is fixed and determinate, and each system represents a portion of time as well as a series of rocks—a portion of time in world-history, just as certain reigns and dynasties and nationalities represent successive stages in the history of the human race:—



CHRONOLOGICAL SUCCESSION OF BRITISH STRATIFIED SYSTEMS.

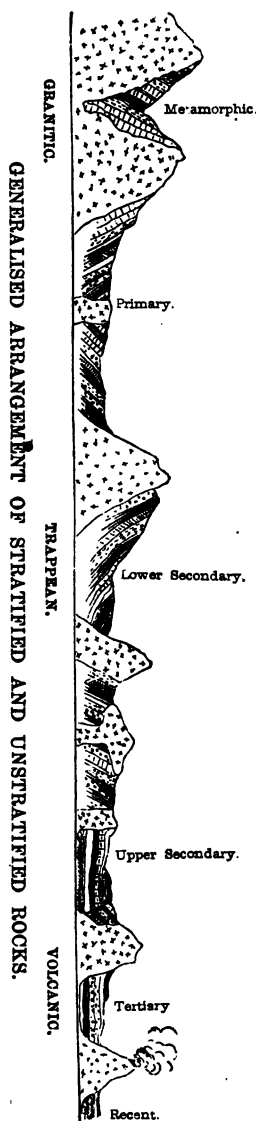
30. As the stratified rocks have been arranged in chronological sequence, so also the unstratified or igneous admit of a similar, though less precise, arrangement. As at present, so during every former epoch of the earth's history, the volcanic forces have been in a state of activity—breaking up the stratified crust, throwing out lava and other products in the formation of hills, and filling up earthquake-fissures with molten rock-matter from below. In course of the earth's mutations these earlier products become submerged beneath the waters of the ocean, and overlaid by newer sedimentary deposits, again to be broken through by another set of igneous operations, and this consecutively and continuously from the most distant ages up to the present day. As a general rule, the earliest igneous rocks will be associated with the earliest stratified deposits, and the older and deeper-seated will be more uniform and crystalline in texture than the newer and more superficial. Founding on principles such as these, geologists usually arrange the igneous or unstratified rocks in the following chronological order:—

1. VOLCANIC, associated chiefly with Tertiary and Upper Secondary strata.
2. TRAPPEAN, associated chiefly with Secondary and Upper Primary strata.
3. GRANITIC, associated chiefly with Primary and Metamorphic strata.

Or, arranging them diagrammatically with the stratified systems, we have something like the annexed connection:—

31. The consideration of these systems and subdivisions forms the special subject of geology; but as each formation occupies a distinct portion of the earth's crust, consists of different kinds of rocks, and presents different soils and surfaces to the geographer, it may be of use briefly to epitomise:—

1st. That the *Post-tertiary System* consists in the main of clays, gravels, sands, peat-mosses, marls, coral-reefs, and other superficial accumulations that have been formed in ancient lake-basins, river-valleys, estuaries, and shallows of the ocean, within a comparatively recent period. They imbed, in a sub-fossil state, the remains of plants and animals still existing, but frequently removed from, or extinct in, certain localities which they once inhabited. In volcanic districts they are associated with recent lavas, scorise, and similar products; and, generally speaking, they occupy low-lying tracts, and constitute the surfaces of valleys, plains, and other alluvial expanses. Associated with these superficial accumulations, but for the most part lying beneath them, there occur all over the northern hemisphere thick deposits of clay and gravel imbedding huge water-worn blocks or *boulders*; and as these seem to point to a time when large areas of the northern hemisphere were under ice, or subjected to the drift of icebergs that dropped their burdens of clay, gravel, and boulders on the then submerged surface, this period is generally known as the



Boulder, Northern Drift, or Glacial epoch, and holds a place intermediate between the Post-tertiary and true Tertiary systems.

2d. The *Tertiary System* consists, in general terms, of clays, gravels, sands, limestones, marls, and lignites or beds of wood-coal; and occupies well-defined areas, as if these at one time had been extensive fresh-water lakes, estuaries, and inland seas. The fossils imbedded in tertiary strata, though closely allied to existing genera and species, are in many instances extinct (especially the gigantic quadrupeds, which is one of its characteristic features), and point to conditions of climate and distributions of life very different from those at present prevailing. The igneous rocks associated with them are lavas and basalts, the products of volcanoes, long since extinct, or now but partially active. Undulating lowlands may be said to constitute the physical features of tertiary districts—the pampas of Buenos Ayres, and the basins of London, Paris, and Vienna, being typical examples.

3d. The *Cretaceous or Chalk System* (Lat. *creta*, chalk) consists, as its name implies, of thick beds of chalk or soft marine limestones, associated with sands, sandstones, clays, and in some localities with beds of coal and lignite. The fossils belong almost wholly to extinct species; and even where the chalk beds are wanting, the other strata are so replete with their characteristic marine remains, that there is generally little difficulty in recognising the system. The associated igneous rocks are chiefly basalts and greenstones; and the physical features of the system may be said to be low rounded hills, with dry intermediate depressions, where the chalk and sands prevail, and flat fertile vales, where the rich organic clays come to the surface.

4th. The *Oolitic or Jurassic System* consists largely of limestones, alternating with calcareous clays and sandstones, bituminous shales, and occasional beds of ironstone and coal. It derives its former name from its peculiar limestones or roestones (Gr. *oon*, egg; *lithos*, stone), which consist in many instances of rounded grains like the roe of a fish; and its latter from its abundant development in the Jura Mountains. As a system, it occurs in many parts of the world, and is characterised by its abundant marine remains, land plants of sub-tropical growth, and especially by the profusion of large nautilus-like shells (*Ammonites*) and gigantic land and water reptiles. The unequal wasting of its harder limestones, and softer clays and shales, confer on the oolitic landscape an agreeable succession of easy undulations; and unless where thrown up into higher hills by volcanic forces, this gradual alternation of hill and dale is the characteristic geographical feature of the system.

5th and 6th. The *Triassic* and *Permian Systems*, which were formerly considered as one great formation under the name of the *New Red Sandstone*, consist in the main of soft reddish sandstones, yellowish magnesian limestones, and variegated clays and marls, with occasional deposits of rock-salt. The lower portion, being largely developed in Perm in Eastern Russia, has given rise to the term Permian; and the upper, consisting in Germany of three well-marked members (sandstones, limestones, and marls), has received the name of Trias, or triple group. The fossil remains of these systems are chiefly marine, with footprints of birds and amphibious reptiles. The physical features of the new red sandstone are by no means decided—the limestones and harder sandstones forming inconspicuous hills and ridges, the softer clays and marls being worn into vales of a flat, wet, and retentive character.

7th. The *Carboniferous System*, so called from its yielding the main supply of coal (Lat. *carbo*, coal) in Europe and America, consists of sandstones, shales, clays, limestones, ironstones, and coals in frequent alternation, as if they had been deposited for ages in seas and estuaries, subjected to repeated subsidences and elevations. The fossils of the system are abundantly marine, estuarine, and terrestrial—the most notable being that excess of vegetable growth that went to the formation of numerous seams of coal. Belonging to the Palæozoic or far-back ages of the world, these remains have but little relationship to existing genera and species, and the highest known forms are merely fishes and reptiles—no bird or quadruped having yet been detected beneath the new red sandstone. With the exception of the trap hills (greenstones, basalts, tufas, &c.) that intersect the system in some localities, and those bold cliffs and scars of limestone (mountain limestone) so characteristic of Yorkshire and Derbyshire scenery, there is little attractive in the physical features of the coal-formation, monotonous moorlands of cold retentive soil being a common occurrence in the geography of the system. Like all the older systems, however, it is rich in mineral and metallic products—coal, lime, iron, lead, zinc, silver, and antimony being among its most important contributions to modern industry and civilisation.

8th. The *Old Red Sandstone* or *Devonian System* (from Devonshire, where a portion of it is typically developed) consists in the main of red sandstones, conglomerates, and shales, with subordinate beds of limestone. It abounds in ordinary marine fossils—corals, shells, crustacea, and fishes; but no higher life than fishes has yet been discovered in its strata, and its vegetable remains are, on the whole, very scanty and imperfect. Thrown into many irregularities by trap eruptions, the physical features of the old red

sandstone are often varied and picturesque, and in general its slopes are dry and of moderate fertility.

9th. The *Silurian System* (so called from its typical development in that district of Wales anciently inhabited by the Silures) consists of numerous slaty or hard shaly beds, with sandstones, conglomerates, and intercalated limestones. As in all the older and deeper-seated rocks, there is often a tendency to crystalline structure among its strata, and these are not unfrequently traversed by metalliferous veins—tin, copper, silver, and gold. Its fossils are eminently marine, and consist almost wholly of the lower or invertebrate orders (corals, shellfish, and crustacea), few fishes being found in its strata, and these only in the upper portions of the system. Flanking and often borne up by the older granitic hills, the physical features of the formation are frequently irregular and mountainous, but, from the softer nature of the rocks, are more rounded and massive, and less abrupt and precipitous, than those of the crystalline or metamorphic system.

10th. The *Metamorphic System* (so called because its strata have undergone a metamorphism or change by heat, pressure, and chemical change, from ordinary sandstones, shales, and limestones into hard crystalline schists), consists of such rocks as gneiss, quartz-rock, mica-schist, clay-slate, and primitive marbles. They yield no fossils; but whether all traces of life may have been obliterated by the mineral change these rocks may have undergone, or whether they were deposited before life existed on the globe, Geology cannot determine, and merely expresses the fact by the term *Hypozoic*, which signifies lying beneath the strata that are decidedly fossiliferous. These crystalline schists are generally found at high angles, flanking or composing the main mass of the older mountains; and from their hard splintery nature present those peaks and ridges that confer on primitive districts their bold, wild, and alpine character.

32. Such are the leading features of the stratified systems, and by such, with a little field-practice, they may be readily detected in the various areas they occupy. As with the stratified so with the unstratified, each great group has its own peculiar features, and though perhaps less sharply defined, they are still sufficiently distinct to be recognised in hill and mountain ranges as volcanic, trappean, and granitic :—

1st. The *Volcanic*, as already stated, are generally associated with the more recent formations, and consist of trachytes, basaltic lavas, vesicular lavas, scorize, and other similar products—loose and less consolidated in the more recent and active, and harder and more compact in the older and extinct volcanoes. They rise

up in dry rocky hills, more or less conical and crateriform; and these are, perhaps, more frequently grouped round some common centre than arranged in linear or axial directions.

2d. The *Trappean*, so called from the terraciform aspect of many of the hills they compose (Swedish, *trappa*, a stair), consist of greenstones or whinstones, basalts, felstones, porphyries, tufas, and other kindred rocks, and are generally associated with the secondary and upper primary strata. They are usually arranged in hill-ranges more or less persistent, and from their higher antiquity and longer subjection to wasting influences, are more worn into rounded heights, exposed crags, slopes, and terraces, which confer on the landscape a beauty and diversity peculiarly their own. Their soils being dry and genial, the trap hills of a country are generally possessed of great amenity and fertility, and constitute, perhaps, the most valuable agricultural portions of the district in which they occur.

3d. The *Granitic*, or oldest series of igneous rocks, consists of granites, syenites, porphyries, serpentines, and the like, which, from their more ancient and deep-seated relations, are generally hard and crystalline in texture and massive in structure. They constitute the nucleus or backbone, as it were, of all the higher and older mountain-chains—elevating the metamorphic schists into splintery peaks and abrupt ridges, or presenting of themselves broad massive shoulders of cold sterile moorland and unprofitable heath.

Connection between Geology and Physical Geography.

33. Understanding the nature of the preceding subdivisions, the student will be able to attach some intelligible idea to such phrases as the river "cutting its way through secondary strata;" "lying in an irregular tertiary basin;" "crossing a plateau of triassic sandstones;" "a cold retentive soil derived from the subjacent carboniferous rocks;" "intersected by a low range of trap hills, whose grassy slopes and terraces;" "bounded by sterile granitic ridges, whose snow-clad summits;" and hundreds of others that are of continual occurrence in geographical descriptions. He will still more fully perceive the intimate connection of geology with his own immediate science when he reflects that many of the soils which give character and colouring to vegetable growth are derived directly from the disintegration of the subjacent rocks, and are further affected in their fertility by the porous or retentive nature of the beds on which they rest. Th

soil derived from the Chalk, for instance, is light and absorbent—hence the short sweet herbage of the “downs” of the south of England; that derived from the marls of the Trias is stiff, retentive, and less fitted for tillage than for pasture; the disintegration of trap rocks, rich in soda, potash, and lime, yields a fertile genial soil, which their structural fissures ever keep dry and pulverulent; while the scanty disintegration of an impervious granite is poor, cold, and barren. We have seen, moreover, that every geological formation is less or more characterised by its own special features. The soft rounded outlines of a chalk range is altogether distinct from the slopes, terraces, and conical heights of secondary trap hills; while these, on the other hand, are widely different, both in outline and in vegetable covering, from broad-shouldered mountains of granite, or the splintery peaks of metamorphic strata. In fine, these formations and rock-groups constitute the framework on which the geographical features are moulded; and their inherent characters, as subject to external and internal change, have produced, and are ever producing, new variety of superficial aspect. Every hill that volcanic energy raises above the general surface, every inequality produced by earthquake convulsion, every glen eroded by river-action, every plain formed by the deposition of alluvial silt, and every inch that one region is elevated above the ocean, or that another may subside beneath it, disturbs the existing geographical equilibrium, confers new features on the landscape, and modifies the habitats of vegetable and animal existences. Geology and geography are inseparably connected; and thus it is that some acquaintance with the nature and sequence of the rock-formations that constitute the solid crust, and with the causes that produce them, becomes so indispensable to the student of physical geography.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter we have directed attention to the rocky structure of the globe as that which gives colour and character to all external phenomena, and is therefore of paramount importance to the student of physical geography. We have spoken of the “crust” composed of materials that can be seen and investigated as distinct from the “interior,” of which nothing can be known by direct observation. This crust, composed of stratified and unstratified, or of water-formed and fire-formed

rocks, is held in habitable equilibrium between the disintegrating forces of water from without, and the reconstructing forces of fire from within. To these two opposing powers are chiefly owing the continuous geological modifications of the earth's crust—each modification representing a period during which certain rocks were formed, and the remains of plants and animals that then lived entombed in them in greater or less perfection. These formations being arranged by the geologist in chronological sequence, and each varying in mineral character, and consequently conferring on the landscape different aspects, it is of importance in physical geography to know the order of this arrangement, and the nature of these distinctions. These *formations*, we stated, had been arranged into certain *systems*, and these systems again grouped into certain *periods*, according to the leading features of their fossils, thus:—

1. Post-Tertiary.	}	CAINOZOIC.
2. Tertiary.		
3. Cretaceous.	}	MESOZOIC.
4. Oolitic.		
5. Triassic.		
6. Permian.	}	PALÆOZOIC.
7. Carboniferous.		
8. Devonian.		
9. Silurian.		
10. Metamorphic. ...		HYPOZOIC.

As with the stratified so with the unstratified—their arrangement into *Volcanic*, *Trappean*, and *Granitic*, expressing the relative antiquities and nature of the great igneous groups that give character and individuality to the hills and mountain-ranges of the globe. So far, then, as diversity of surface, fertility of soil, character of landscape, and similar peculiarities, are concerned, the connection between physical geography and geology is intimate and inseparable; and hence the necessity that the student of the one should be less or more acquainted with the leading facts of the other. It by no means follows, however, that the student of geography should be deeply read in the theoretical problems of geology. An acquaintance with its general principles, and the causes that are incessantly productive of new modifications of the earth's crust, the leading formations that compose that crust, the nature of their rocks, and the character which these impart to the soil and landscape, is all, or nearly all, that he requires; and this information he can readily obtain from such manuals of the science as the Author's 'Introductory and Advanced Text-Books,' or Sir Charles Lyell's 'Principles' and 'Manual,' should he wish to extend his information beyond the outline sketched in the foregoing chapter

IV.

DISTRIBUTION OF LAND AND WATER.

Their Relative Positions and Areas.

34. HAVING noticed the general conditions of the earth as a member of the solar system, and having also adverted to the structure of its own rocky crust as the groundwork of all geographical diversity, we now proceed to consider the more intimate relations of its surface, as composed of Land and Water. When we speak of the earth's surface as composed of land and water, we mean that all the more elevated portions of the crust stand out as dry land, while the lower and more depressed are covered by the waters of the ocean. Geologically speaking, the relations of land and water are continually, though slowly, undergoing change and modification; geographically speaking, and within the limits of such mutation, what are the respective areas of land and water, their positions on the earth's surface, their actions and reactions on each other, in consequence of their different extents, positions, capacities for heat, &c., and what the influence of these reactions on currents, winds, rains, and all those kindred phenomena that constitute climatic diversity? The present distribution of land and water tends to the production of certain physical and vital results, and the explication of these results forms the sum and substance of our science; but no portion of the present distribution could be altered either in its position, extent, or configuration, without being accompanied by a modification of these results, so intimately is the one element bound up with the other in the production of a definite and harmonious whole.

35. As formerly stated, the superficial area of the globe has been computed at 197,000,000 square miles. Of this amount about 51,500,000 consists of dry land, and about 145,500,000 of water; or reckoning the whole surface of the globe as equal to 1000 parts, 262 of these parts will consist of land and 738 of water. The

proportion of land to that of water is therefore nearly as *one to three*; or, expressing it fractionally, while *one-fourth* of the earth's surface is composed of dry land, the other *three-fourths* are covered by the waters of the ocean. Considered in hemispheres, northern and southern, the proportions of land and water are nearly as follows:—

Northern Hemisphere,	Land,	38,000,000 square miles.
Do.	do.	Water, 60,500,000
Southern Hemisphere,	Land,	13,500,000
Do.	do.	Water, 85,000,000

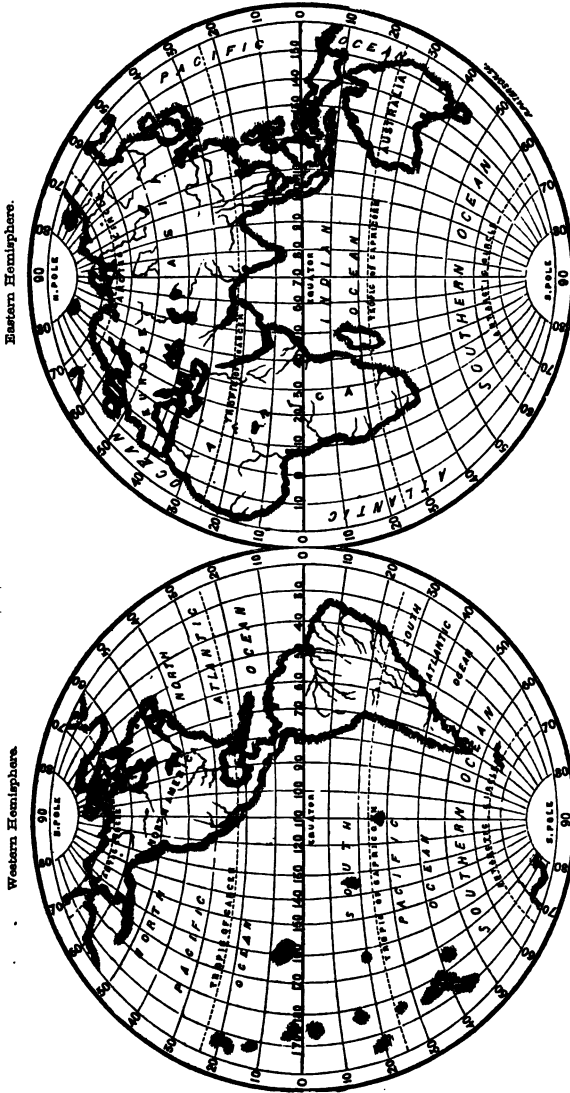
There is thus about three times as much land in the northern as there is in the southern hemisphere; and if we make the estimate in eastern and western hemispheres (20° W. long. to 160° E. long.), there are about 37 millions square miles in the former, while there are only 14½ millions in the latter. As to the distribution of land and water in the different zones, it may be stated, in very general terms, that the land forms about *one-third* of the north frigid zone; *one-half* of the north temperate zone; *one-half* of the torrid zone; *one-tenth* of the south temperate zone—the amount in the south frigid zone being at present unknown. The *mean elevation* above the sea-level of all the land on the globe—islands as well as continents, mountains as well as plains—is estimated by Humboldt at somewhat less than 1000 feet. The *mean depth* of the ocean is calculated by Laplace, from the tides and other phenomena, to be at least 21,000 feet. “Hence,” says Sir H. Holland, “allowing full margin for errors, the entire submergence of the land might take place, leaving the solid mass of the earth everywhere deeply covered with waters,—an elliptical globe of ocean, moving still under the influence of those sublime laws which had before guided its path through surrounding space.”

36. The boundaries of this terraqueous arrangement (Lat. *terra*, land; *aqua*, water) are extremely irregular. Here the land spreads out in broad unbroken masses, there the waters stretch away in vast continuous expanses; here the land rises up in mere specks and fragments, there the water inserts itself among them in areas equally limited and irregular. Here the land juts boldly out into the ocean, there the ocean runs sharply into the land; here the land trends uninterruptedly for leagues, there the ocean embays itself with gentle curves into the bosom of the land. Although this distribution seems to obey no regular order, and has been continually changing throughout all geological time, yet we may rest assured—and not the less assured because we are unable to discover it—that there is a law governing the insensibly varying relations of

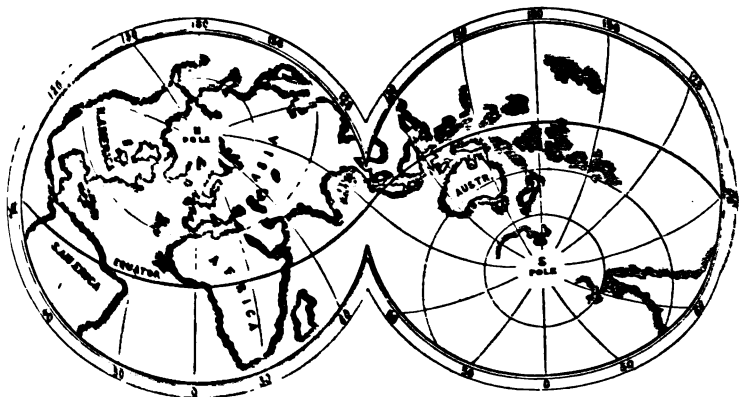
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26. A glance at the Map of the World will show that the land is more situated chiefly in the northern hemisphere—there being about three times as much land in the northern as there is in the southern hemisphere. And if we look at the distribution of this land as regards the zones of temperature, we will find that the greatest proportion is situated in the north temperate zone, or in that which contains all the better portions of Europe, Asia, and North America; while only comparatively narrow or isolated tracts are cut directly by the equator or central torrid line. Another glance at the map will show that while the land lies in broad unbroken masses towards the north, it stretches towards the south in curious gradually-tapering projections. Again, if we suppose the globe to be divided into hemispheres by the plane of the horizon of London (the dividing line being 50° all round from London) we will find that nearly all the land lies in the one hemisphere, while the other is almost wholly occupied by the

T 世界 WORLD.



waters of the ocean. The former (see illustration) is spoken of by geographers as the *Continental* or *Land hemisphere*, while the



Land and Water Hemispheres.

other is termed the *Oceanic* or *Water hemisphere*. These and other noticeable facts connected with the arrangement of sea and land have been often adverted to by writers on geography; and though it must be confessed that many of their comparisons are more curious than suggestive, there can be no doubt that the present arrangement is the result of some great cosmical law—a law concerning the nature of which neither geology nor geography can give any certain indication. This much, however, geology has shown, that the present terraqueous arrangement is not the arrangement that obtained in former ages, and that continents existed where seas now roll, and seas extended where continents are now established. We can readily account for the minor modifications of coast-lines—why some portions, composed of hard enduring rocks, should stand out in bold projections; while others, consisting of soft and wasting material, should be worn into bays and irregular recesses; but of the greater forces that slowly upheave some regions and as gradually submerge others, we are altogether ignorant. But while we fail to account for the present distribution of sea and land, and while we find that it is continually undergoing modifications under the operation of geological forces, we know that these changes are so silent and gradual as scarcely for ages to interfere with our ideas of geographical permanence and stability.

Their Subdivisions, Natural and Technical.

38. Admitting this condition of the terraqueous surface, it will be seen, on further reference to the Map, that the land is broken up into two main masses—that of the Eastern hemisphere, embracing Europe, Asia, and Africa, and described, from its being the only portion known to the ancients, as the *Old World*—and that of the Western hemisphere, including North and South America, and known (from its comparatively recent discovery by Columbus in 1492) as the *New World*. Properly speaking, there are only two great continuous land-masses or *continents* (Lat. *con* and *tenens*, holding together)—that of the Old World and that of the New; but geographers usually speak of six continents or principal sections,—viz., those of *Europe, Asia, Africa, North America, South America, and Australia*. Australia and its contiguous islands, together with those of the Southern Ocean, are frequently grouped as the sixth great division, under the title of *Oceania*; while others, drawing more restricted lines, speak of Australia and New Zealand as *Australasia*, and of the many islands of the Pacific proper as *Polynesia*.* The areas of the respective continents, or *quarters*, as they are sometimes termed (though the “four quarters” of our forefathers embraced only Europe, Asia, Africa, and America), have been computed, with their respective islands, as follows:—

Old World, or Eastern Continent, . . .	31,250,000 square miles.
Europe, . . .	3,725,000 ”
Asia, . . .	16,165,000 ”
Africa, . . .	11,360,000 ”
New World, or Western Continent, . . .	14,900,000 ”
North America, . . .	8,080,000 ”
South America, . . .	6,820,000 ”
Oceania, or Maritime World, . . .	4,200,000 ”

39. The islands included in the above estimate are more or less closely connected with the continents to which they belong, though in truth the continents themselves are merely islands on a much

* The subdivisions Australasia or Southern Asia (*australis*, southern) and Polynesia, or many islands (*polys*, many; *nesos*, island), are sufficient for our present purpose; but the student may as well understand that many geographers and ethnographers speak of the East Indian Archipelago as *Malaysia*; of Australia, Papua, New Zealand, and the minor contiguous islands as *Australasia* or *Melanesia* (*melas*, black), in reference to the colour of their aboriginal population; of the numerous small Pacific islands north of the equator and east of Malaysia as *Micronesia* (*micros*, small); and of the many groups lying south of the equator and east of Australasia as *Polynesia*.

larger scale. In the disposition of the islands some curious coincidences have been noticed by German geographers, but these resemblances are in many instances more fanciful than real, and have no discoverable bearing either on the problems of geology or geography. Many of the larger islands—as Iceland, Spitzbergen, Novaia Zemlia, Madagascar, and the like—are solitary and independent; others again—as Tierra del Fuego, Sicily, Ceylon, Tasmania, &c.—are curiously connected with the extremity of some peninsula and continent, to which they form, as it were, mere outliers; while, in a majority of cases, the islands proper are found in clusters or *Archipelagos* (a term originally applied to Isles of Greece), such as the West India Islands, the Isles of Greece, the East India Islands, the Japan Isles, the Sandwich Islands, and many other groups that must at once present themselves on the most cursory inspection of the Map of the World. This disposition is no doubt in intimate connection with geological centres of uprise or depression—uprise into new continental areas, or depression into new seas; but the consideration of such oscillations in the earth's crust belongs more appropriately to Geology than to Physical Geography.

40. In describing the features and peculiarities of the Land, geographers make use of the following designations, which, though familiar in everyday language, may here, for the sake of method, be briefly recapitulated. Thus, a *continent*, as already indicated, is any extensive region uninterrupted or unbroken by seas; an *island*, any smaller portion surrounded by water; a *peninsula* (Lat. *pene*, almost; *insula*, island), a portion nearly surrounded by water; an *isthmus* (Gr.), the narrow neck that connects two adjacent masses of land, or a peninsula with the mainland; and a *cape*, *promontory*, *headland*, or *ness*, a point of land jutting out into the water. Besides these terms, which refer to the contour or disposition of the land as connected with water, there are others which relate to surface configuration or vertical relief. Thus, extensive flats are known as *plains*, *steppes*, *prairies*, *pampas*, and the like; smaller flats as *valleys*, *dales*, *straths*, *carse*, &c.; elevated more or less abruptly above the general surface are called as rising into *hills*, or still higher into *mountains*; hills and mountains may stand less or more apart from each other and may occur in groups as if connected with a common any stretch away in determinate courses known as *ranges*; while level elevated tracts are spoken of as *plateaus*.

surrounding the globe on every side, and in all its parts connected with our great ocean, the Water is still

divisible into certain areas that are more or less defined by the intervention of the land. Thus, on the west of the Old World, and between it and the New World, extends one main division known as the *Atlantic* (so called by the ancients from its washing the western base of Mount Atlas in Africa); on the west of the New World, and between it and the Old, expands another natural division known as the *Pacific* (from its comparative freedom from storms); while between Australia and its contiguous islands on the east and Africa on the west, lies the *Indian Ocean*. It is usual, however, to speak of *five* great oceans—viz., the *Atlantic*, *Pacific*, *Indian*, *Arctic*, and *Antarctic*—the two latter being respectively within the arctic and antarctic circles. In geographical descriptions it is also useful to employ the terms “North and South Atlantic,” and “North and South Pacific,” and to speak of the expanse that stretches away in unbroken vastness between the Indian Ocean and the south pole as the “Great Southern Ocean.” The areas of these respective expanses are usually estimated as follows :—

Pacific Ocean, . . .	50,000,000 square miles.
Atlantic Ocean, . . .	25,000,000 ,,
Indian Ocean, . . .	17,000,000 ,,
Arctic Ocean, . . .	? ,,
Antarctic Ocean, . . .	! ,,

Being ignorant of the amount of land that lies within the arctic and antarctic circles, and also of the exact extent of many islands both in the northern and southern oceans, the above must be taken as approximations merely; and, further, as amounts that do not embrace the areas of minor and *inland seas*—such as the North, Baltic, Mediterranean, Red, Black, Caspian, &c.—which occupy considerable spaces on the surface of the globe, and which exercise, moreover, a much greater influence on its climate, produce, population and industry, than their mere surface spaces would imply.

42. In treating of the waters of the globe, though there is, strictly speaking, only one great ocean, the term *ocean* is applied to the large uninterrupted expanses above defined; smaller areas are known as *seas*; gradual bendings of the water into the land as *bays*; deeper indentations as *gulfs*; minor and sudden indentations as *creeks*, *inlets*, *arms*, &c.; the narrow belts or openings connecting two adjacent seas as *straits*, or *channels*; and where the sea stretches inland to receive the waters of a river, such an expanse is known as a *frith* or *estuary*. Besides these general terms, there are others of a more local and restricted character, as the *fjords* or rocky inlets of Norway—the *lochs*, or lake-like sea-arms of Scotland—the *lagoons*, or shallow intercepted sheets that occur along

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Obi in Asia; and the Volga and Danube in Europe. Springs, streams, rivers, lakes, and seas thus constitute what may be termed the geographical phases of water, or, in other words, its position and disposition on the earth's surface. Water, however, is circling everywhere, and is everywhere present, either in its aëriform, liquid, or solid condition. Floating in the air that surrounds us, circulating in the tissues of plants and animals, embodied in the substance of the hardest rocks, coursing over the earth's surface, or percolating deep in the solid crust, it is the great vital fluid of nature, by which the whole is permeated, combined, dissolved, reconstructed, and vivified in endless revolution and progress.

Their Mutual Actions and Reactions.

44. Such is the relative distribution, and such the general features, of the land and water that form the surface of the terraqueous globe. Whatever may have been their distribution in former ages as revealed by Geology, one thing is obvious, that in the present era they are, within certain limits of change, mutually adapted and harmoniously adjusted. The land absorbs and radiates the sun's heat more readily than the water; and thus, while parched and thirsty in summer, it is refreshed and vivified by the moisture evaporated from the more extensive ocean; while in winter its tendency to grow colder is modified by the heat given off by the ocean, whose slower radiation renders it, as it were, a great storehouse of latent heat for the exigencies of the land. Besides this interchange of heat and moisture, there is also the interchange of aërial currents and winds, caused by the unequal capacity of the two great surfaces for heat; and thus, as will be more fully explained hereafter, the whole machinery of climate—hot winds, cold winds, vapours, rains, and the like—is set agoing by the primary differences existing between land and water. As at present distributed, a certain amount of moisture is evaporated from the ocean and carried to the land, a certain amount of heat is interchanged—certain winds blow at certain seasons, certain tides rise and fall, and certain currents flow in the performance of certain functions; but all this would be changed by the slightest alteration either in the relative areas, in the relative configurations, or in the relative positions of land and water. In their present areas, configurations, and dispositions, the two elements are harmoniously adapted for the production of certain results, geological, climatological, and vital; and the student must readily perceive how the force of tides and waves and currents would

altered, the climate of regions changed, and their plants and animals affected by the slightest disturbance in the existing terraqueous arrangements. Let North and South America be severed by the disappearance of Panama—let the bed of the Atlantic be upraised so as to deflect the Gulf Stream on the coasts of Greenland instead of those of Europe—let the central plain of Europe be submerged so as to be occupied by another Mediterranean,—let these, or any similar set of changes be effected on the present arrangement of the continents and oceans, and a whole host of new secondary influences would be set in motion, altering the climates and modifying the kind and character of the plants and animals that people these regions. So intimately, in fact, does the conditions of the one element depend upon those of the other, and plants and animals upon both, that not a league of land could be converted into sea, or a league of sea-bed upheaved into dry land—the land raised a foot higher or the sea become a foot deeper—without a corresponding change being effected on the whole economy, physical and vital, of our planet.

From Nature's chain whatever link you strike,
Tenth or ten-thousandth, breaks the chain alike.

NOTE, RECAPITULATORY AND EXPLANATORY.

The facts detailed in the preceding chapter are so simple and obvious, that they require little recapitulation or further explanation. The surface of the globe, or that which comes in contact with the atmosphere, is partly occupied by land and partly by water—the former constituting more than a fourth, and the latter about three-fourths of the entire area. On a cursory inspection of the map of the world, the land will be seen to resolve itself into two main masses—the Eastern hemisphere or Old World, and the Western hemisphere or New World; and these by geographers are usually further subdivided into the so-called “quarters” or continents of Europe, Asia, and Africa in the former; North and South America in the latter; together with a south or insular division, embracing Australia, &c., under the name of Oceania. Of these continents the greater portion lies in the northern hemisphere, the broader masses spreading out towards the north, and gradually narrowing towards the south in the cape-like projections of South America, Africa, Hindostan, and the Malayan Peninsula. The

ocean, though encircling the globe on every side, and stretching from pole to pole, is also arranged in areas more or less defined by the intervention of the land-masses. The main divisions are the Atlantic, the Pacific, Indian, Arctic, and Antarctic Oceans, which, for convenience of description, are frequently subdivided into North and South Atlantic, North and South Pacific, Northern, Southern, and Polar Seas. The technicalities employed in treating of the relations of land and water—shore-line, coast-line, island, peninsula, isthmus, cape, bay, gulf, strait, channel, and the like—are so obvious, and of such frequent use in everyday language, as scarcely to require any special explanation. The physical results arising from the present distribution of sea and land are manifested chiefly in tides, currents, unequal reception and radiation of the sun's heat; and as a consequence, winds, vapours, rains, and all the other phenomena that give rise to climatic diversity. What may be the proximate cause of the present arrangement of sea and land—why the land should lie chiefly in the northern hemisphere, and largely within the temperate zone, while it disappears in a succession of narrow cape-like lobes towards the south—neither Geology nor Geography can determine. One thing, however, is certain, that it is part of a great geological sequence of continuous oscillations between sea and land, each change being attended by its own physical and vital phenomena; and that, as in the past history of the globe, so in the present, no alteration in this terraqueous arrangement can take place without a corresponding alteration in all the essentials of Physical Geography.

For the minor subdivisions of land and water, which are arbitrary and political, rather than physical, the student may consult Mackay's 'Manual of Modern Geography,' or any similar work equally recent and ample in its information.

THE LAND—ITS CONFIGURATION.

45. HAVING glanced at the distribution of land and water, and their general relations to each other, as composing the terraqueous surface of the globe, we now proceed to consider their special features—the mountains, table-lands, plains, and valleys of the one—the composition, depth, temperature, tides, and currents of the other. And first, in the present chapter, of the Land, whose features are more within our reach, and have been longer and more minutely the subjects of geographical investigation. How is this dry land disposed on the surface of the globe? This is its *position* as depending on latitude and longitude. What the outline of its form or shape as regards the ocean, by which it is on every side surrounded? This, in geographical language, is its *contour*. How, again, does it rise above the waters: and what the surface inequalities presented to the atmosphere? This is its *vertical relief*. Position is the place it occupies on the surface of the globe; contour the outline bathed by the waters of the ocean; vertical relief the surface-line that rises into the atmosphere; and the student will readily perceive that upon these three elements of position, contour, and relief, depend the climate, physical aspects, and vital diversity of any portion of the dry land.

Relative Position.

46. Latitude and longitude, we have said, determine the position of a spot on the earth's surface, be it islet, island, or continent; but as these limits bring it within tropical, temperate, or frigid zones, so will its climate and products assume aspects of a corresponding character. How different the physical and vital aspects of Europe and Asia had they lain mainly within the tropics, stretching, as they now do, mainly along tem-

perate latitudes! How different also the condition of North and South America if, instead of stretching from north to south, through all the different zones of temperature, they had lain, like the Old World, from east to west, along the same parallels of latitude! And how altered, in like manner, had been the physical, vital, and perhaps also the intellectual, characteristics of Great Britain, if, instead of trending northward and southward, between the 50th and 60th parallels, it had stretched westward to the same extent into the waters of the Atlantic! Position, in fact, is an all-important element in geography; hence the value of accurate mapping, and a knowledge of this mapping to every one, whether engaged in commercial pursuits or in the study of natural phenomena. The cause of the present position of the dry land lies far, as yet, beyond the indications of science. We learn from Geology that the existing position is not that which obtained in former ages; and that, in fact, every epoch was characterised by its own special distribution of land and water. The consideration of these alternations belongs to Geology: Geography has mainly to deal with the existing aspects of nature.

Contour or Horizontal Outline.

47. Though Geology and Geography are alike unable to account for the present disposition of sea and land, there are still some features in the contour of the respective land-masses that demand a passing notice. Not that we know the producing cause of these features, nor that they are deserving the attention occasionally bestowed upon them, but simply because they are arrangements productive of obvious results, and as such are clearly significant of purpose and design. Thus, though the greater bulk of the land lies in the northern hemisphere, the greatest extension of the Old World continent is from east to west, while that of the New World is from north to south. In this way, the Old World, lying largely along the same zones, presents a greater uniformity of external conditions; while the New World, crossing the zones—frigid, temperate, and torrid—is subject to a greater diversity of temperature, and, as a consequence, to all the conditions that arise from this diversity. 2. Both continents attain their greatest dimensions from east to west along the same parallel of latitude, namely, that of 50° N.—a disposition that places much of North America, Europe, and Asia within the temperate zone, while only the narrower portions of South America, Africa, and the East India Islands lie directly under the burning heat of the equator. 3. Both continer

as formerly noticed, spread widely towards the north, where they nearly approach each other, and terminate broadly along the same parallel (72° N.) or nearly so; while, towards the south, they gradually grow narrower, and terminate in far-separated promontories. Indeed, the southward trending of the great lobes of South America, Africa, and Australia, and their separation from their main continents by narrow isthmuses or islands, has suggested the analogy of three double worlds—North and South America, Europe-Africa, and Asia-Australia—a curious coincidence certainly, which a glance at the map will readily confirm. 4. In like manner, the direction of all the principal spurs and peninsulas in both continents (California, Florida, Greenland, Scandinavia, Spain, Italy, Greece, Hindostan, Malaya, Kamtchatka, &c.) is towards the south—a feature by far too general not to suggest to the inquiring mind a sameness in the producing cause. 5. These southward-trending spurs, moreover, are in most instances curiously accompanied by an outlying island or islands—as South America by Tierra del Fuego and the Falkland Islands, Africa by Madagascar, Hindostan by Ceylon, and Australia by Tasmania. And in connection with this may be noticed the fact, that these promontories terminate in abrupt rocky precipices—as Cape Horn, in Tierra del Fuego; Cape of Good Hope, with its Table Mountain; Cape Comorin, in India; and Cape South-East, in Tasmania—all the broken and worn extremities of expiring mountain-chains.

48. Continuing these analogies, we may notice, 6. The general disposition of the continents and larger islands in the direction of their principal mountain-axes; so that, given the direction of the mountain-chains, we know the longitudinal disposition of a continent, or given the direction of a continent, and we can foretell the strike of its mountains. 7. The almost complete separation of South America from North America, of Africa from the Old World, and the severance of Australia from Asia; as well as the curious resemblance that obtains between North America with the West India Islands on its south-east, Europe with the Grecian islands on the south-east, and Asia with the Indian Archipelago in the same quarter, are curious coincidences that have been long noticed by geographers. 8. The general tendency of islands to arrange themselves in clusters or archipelagoes, is a fact also suggestive of a common geological cause. And, lastly, the numerous indentations of the sea, that confer irregularity and extent of coast-line on the land in the northern hemisphere, is a feature that strongly contrasts with the uniform and unbroken coasts of South America, Africa, and Australia, in the southern hemisphere. Indeed, this last relation of a broken and deeply indented coast-line, furnished

with peninsulas, gulfs, inland seas, and harbours—is one of the most important in Physical Geography, as on it depend greater diversity of climate and productions, and all those facilities for navigation and commerce which confer on nations their wealth, power, and independence. Europe and North America stand pre-eminent for their relative extent of coast-line; and hence in a great measure their industry, maritime enterprise, and civilisation. Assuming that the capacity of a country for external communication can in some degree be estimated by the proportion of its coast-line to its superficial area, the following tabulation will briefly exhibit this relation:—

	Square miles, statute measure.	Length of coast in stat. miles.	Square miles for 1 mile of coast.
Europe, . .	3,400,000	20,000	170
Asia, . . .	17,600,000	33,000	533
Africa, . .	11,300,000	16,500	680
North America,	7,200,000	28,000	260
South America,	6,800,000	16,500	420
Australia, .	3,500,000	7,600	460

Here it will be seen that Europe has 1 mile of coast for every 170 square miles of surface, and North America 1 mile of coast for every 260 square miles of surface—a proportion more than double that of the other continents; hence one great physical reason for the commercial and industrial supremacy of their populations.

49. Besides the preceding analogies, there are several others that have been noticed by geographers; and though such comparisons are often more fanciful than real, they are all less or more suggestive, and may occasionally lead to a satisfactory theory. But whatever may have been the causes that produced the present arrangement of the land-masses, no change could take place in their relative situations without being attended by corresponding changes in the nature of their climate, and in the character of their vegetable and animal inhabitants. Had they lain chiefly within the tropics—been situated partly in the northern and partly in the southern hemisphere, with a broad belt of tropical ocean between—been arranged either longitudinally or latitudinally in parallel zones, or been broken up into smaller masses by the more frequent intervention of the ocean—a totally different set of climatic agents would have prevailed, and been consequently attended by a totally different distribution of plants and animals. During geologic changes, when large tracts are being gradually submerged and others are gradually elevated into dry land, whole races of plants and animals are extinguished, while others shift ground and find means of dispersion over the newly elevated regions. At present the plants and animals of the Old World differ from those

of the New, those of North America differ considerably from those of South America, those of Europe from those of Africa, and those of Asia from those of Australia; but these differences would have been still more striking and decided, had these continents lain still more apart, or been more widely separated in their geological connections. As it is, and in the language of an eloquent authority, "each of these terrestrial masses, considered as a whole, as an individual, has a particular disposition of its parts, of the forms which belong to it—a situation relatively to the rays of the sun, and with respect to the seas or the neighbouring masses—which is not found identically repeated in any other. All these various causes excite and combine, in a manner infinitely varied, the play of the forces inherent in the matter which composes them, and secure to each of them a climate, a vegetation, and animal life; in a word, an assemblage of physical characters and functions which are peculiar to it, and which really give it something of individuality." It is this *individuality* of the land-masses and its discrimination that constitute, in fact, the very purport and essence of Physical Geography.

Vertical Relief or Elevation.

50. Next to the *contour* or horizontal configuration of the land, the most important feature is its *vertical relief*, or elevation above the level of the ocean. As the position of an island a few degrees farther north or south, its disposition along the parallels of latitude or along the meridians, or its configuration as broken up by seas or lying in one unbroken mass, must each affect the nature of its climate, so its vertical relief is productive of similar results—every rise of 300 or 350 feet being sufficient to diminish the temperature one degree of Fahrenheit. Admitting the importance of this element, we may again, for clearness' sake, repeat that a tracing of the line of an island forms its *contour*; its entire surface, as its heights and hollows, constitutes its *vertical relief*; and its surface, as seen against the sky from any one point, forms its *profile* for that direction. If we cannot determine the causes that have produced the existing positions of the continents, we know, at least, that the diversity of their surface into mountain and plain, are the volcanic forces acting from hence to some great law, have been changing place from the earliest traces of time, and extensively, along the old granitic, and Africa—at another, and with equal

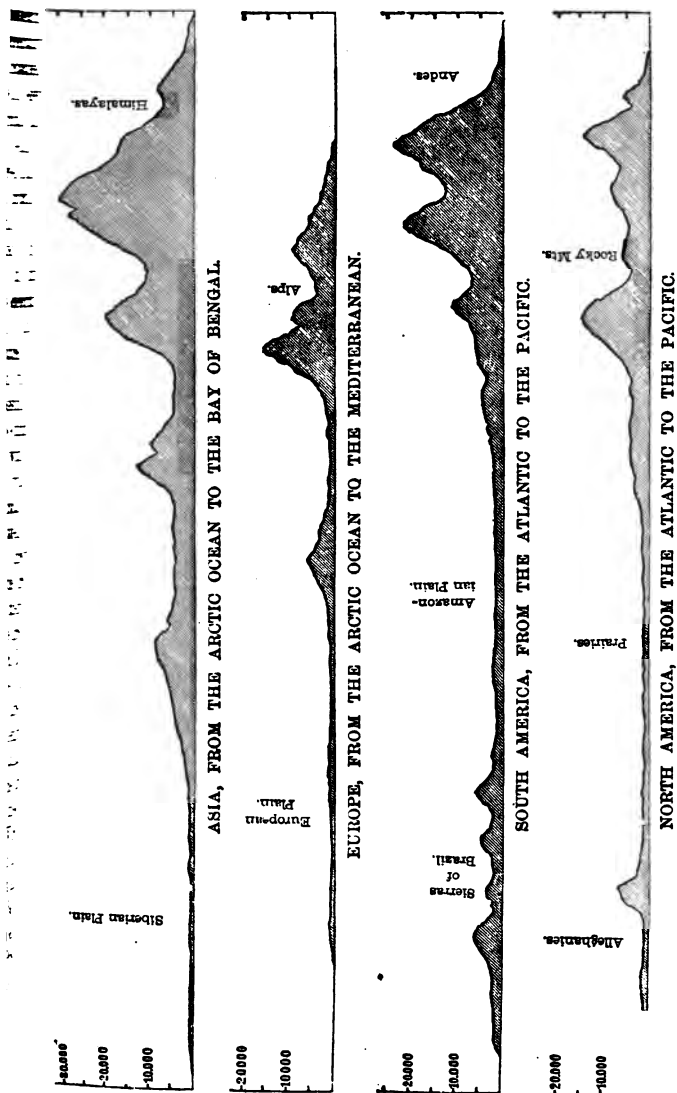
intensity, along the secondary hills of the same continents—and now, with apparently unabated vigour, along the main ridges of America, the islands that fringe the eastern shores of Asia, and the groups that stud the bosom of the Pacific. These successive shiftings and upheavals form, in fact, part and parcel of the great machinery of the world—a machinery by which the sea-bed is upheaved into new land, and old surfaces submerged beneath the ocean, and this continuously, successively, and, in all likelihood, in a determinable order, which Geology will one day or other be enabled to discover. The student cannot cast his eye over the Map of Earthquakes and Volcanoes, and observe the comparative paucity of volcanoes in large tracts of the world, and their great concentration in groups and lines along the shores and over the surface of the Pacific, without being impressed by the conviction that in that region some great cosmical change is in course of elaboration. We say, *in course of elaboration*; for, like all other gigantic operations in nature, the upheaval of continents, and the up-piling of mountains and mountain-chains, are the works of innumerable earthquakes and volcanoes operating through untold ages. Besides the more obvious operations of the earthquake and volcano, there is also that slow but gradual elevation and depression of vast regions (*e. g.*, the uprise of Northern Scandinavia, the depression of South Greenland, the uprise of the Arctic Islands, &c.), which in course of time must effect most important changes; and to these combined forces, assisted by the wasting and wearing of air and water, are to be mainly ascribed the principal features in the vertical relief or superficial diversity of the land.

51. Among these features may be noticed, *first*, That in all the continents there is a gradual rise from the sea-shore towards certain points or ridges in the interior—the spaces occupied by a few depressed areas, as the Caspian, Dead Sea, &c., being so limited and exceptional as not to be regarded as interfering with the general rule. These ridges, or points of maximum swell, form the grand *watersheds* of their respective continents; and a glance at the courses of the principal rivers will at once direct the eye to the line of these mountainous elevations. 2. In all the continents this line of greatest elevation does not occupy the centre, but is placed more towards one side than another; hence arises two slopes of unequal length, the long side forming the *slope*, and the shorter the *counter-slope*, of the continent. In the Old World the long slopes are turned towards the north, and the short towards the south; while in the New World the gentle slope is towards the east, and the short and rapid one towards the west. 3. This difference of arrangement in the slope and counter-slope

place in the two ways is a general flattening of the land towards the north and a general rise and irregularity of its surface towards the south, prevail in all the continents. "The effect of this law of attraction—*is* has been well observed, "is to temper the burning heats of the tropical regions, and to give them a variety of climate which seems not to belong to these countries of the globe. If the order were reversed, and the elevation of the lands went on increasing towards the north, the most civilized half of the globe, at the present day, would be a frozen and uninhabitable desert." It is from considerations of this kind that the student of physical geography perceives the intimate interdependence that subsists between the various departments of nature. You cannot, for example, alter the position of an island without affecting its general climate: you cannot change its contour without causing into play a new set of waves and tides and currents; and you cannot disturb its relief, either by raising a comparatively level surface into billowy irregularities or by smoothing down irregularities into level plains, without interfering with its plants and animals, and, to a certain extent, also with the whole of the relations that subsist between its vegetable and animal economies.

52. As another general law it may be stated, 4. That the grand elevations or mountain-ranges lie in the direction of the greatest length of a continent; in fact, it is the great lines or *axes* of upheaval that confer on the continents their main relief or configuration. Thus, in the New World, whose greatest length is from north to south, the ranges of the Andes and Rocky Mountains, the Cordilleras of Brazil, and the Alleghanies of the United States, stretch all less or more regularly in the same direction. In the Old World, on the other hand, whose greatest length is from east to west, the ranges of the Pyrenees, Alps, Carpathians, Caucasus, Himalayas, and Altai, lie chiefly in the same direction, throwing the great rivers to the north and south of these watersheds. The backbone, if we may so speak, of the New World is the great mountain-chain, or rather chains, that extend in the same linear direction from Patagonia on the south to Russian America on the north—a length of about 8000 miles; while the backbone or framework of the Old World is similarly composed of a series of ranges that extend with but little interruption from the Pyrenees

Kamchatka on the east. 5. As with the continents, the principal islands and peninsulas: they are all continuously traversed by mountain, or hill ranges in the direction of their greatest length—as witness Scandinavia, Kamchatka, Malaya, the islands of the Indian Archipelago, Madagascar, California, and Greenland. In fact, it



is the mountain-ranges that determine the strike of the land, and confer on these spurs and peninsulas their elongated forms—the eruptive rocks bulking in ridges, and carrying the stratified systems high on their slopes and shoulders.

53. Reserving the arrangement of the world's highlands into mountain chains and systems for subsequent consideration, it may be noticed in the mean time that the loftiest ridges in the vertical relief of the land are those of the Himalaya in Central Asia, whose highest peak is, in round numbers, 29,000 feet; next, those of the Andes in South America, 24,000 feet; the Cordilleras of Mexico in North America, 17,740 feet; the Alps in Europe, 15,740 feet; the Abyssinian mountains in Africa, 14,720 feet; and the highest ascertained points in Malaya, Australia, and Polynesia, respectively 15,000 feet, 7000 feet, and 16,000 feet. These altitudes, however, convey no idea of the general relief of the several continents, whose superficial aspects depend more on the table-lands and plains, the hill-ranges and valleys, than on the extreme heights of their principal mountains. Indeed, so small a proportion do these extreme ridges bear to the great mass of the continents, that it has been calculated by Humboldt that the Alps spread equally over the surface of Europe would raise the general level not more than 21 feet; while the vast mountain-chains of Asia, treated in a similar manner, would not add more than 150 feet to the general elevation of that continent. Blending all their heights and hollows into a general average, the *mean elevation* of the respective continents above the sea-level are given by the great German philosopher as follows:—Europe, 1342 feet; Asia, 2264 feet; Africa, 1800 feet; North America, 1496 feet; and South America, 2302 feet. As the surface of the dry land presents its plains and mountains, and the sea-bed its shoals and depths, so it is very easily imagined that the depressions of the one sink in the elevations of the other. For this belief, however, there is no foundation in fact. On the contrary, judging from the vast extent of the ocean, the soundings we already possess of the small mean elevation of the dry land, it seems more reasonable to conclude, with Sir John Herschel, that “the surface of the dry land most probably does not differ much from the mean depth of the bed of the ocean, in the absence of reliable soundings for comparison. It is better to avoid such comparisons, and to deal with the relief of the land on its own merits, and as a measure already determined.

Causes and Consequences of Configuration.

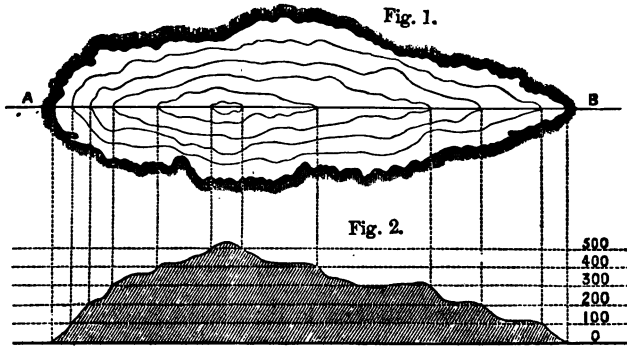
54. It will be seen from the preceding paragraphs that the three great elements in the configuration of the land are relative position, contour, and vertical relief. By *relative position* is meant the place an island or continent occupies on the surface of the globe; and just as this position is frigid, temperate, or tropical—as it lies in broad parallelism along the same zone, or crosses meridionally two or more zones—so will its climate be genial or ungenial, uniform or diversified. The causes that have determined the position of the existing continents lie far, as yet, beyond the indications of science, though we may rest assured that, in the gradual shiftings of volcanic energy from centre to centre, and in the alternate uprise and submergence of large tracts of the earth's crust, we behold the results of a definite and continuously operating law. By *contour* is meant the outline or figure which the land receives by being surrounded by the water; and just as this outline is simple and uniform, or irregular and indented by seas, bays, and gulfs, so will its external conditions be varied, and its coasts better fitted for the purposes of navigation and commerce. This contour depends mainly, of course, upon the original inequalities of the crust, but partly also upon the waste and degradation which all coast-lines undergo from the ceaseless action of the ocean. Combined, as in the case of Europe, with favourable relative position, it exercises most important influences on climate, productions, industry, enterprise, and civilisation. By *vertical relief* is meant the elevation of the land above the level of the ocean: and just as this is regular or irregular, low or lofty, so will the whole character of a country be determined. A few hundred feet more or less of elevation is sufficient to change the whole physical aspects of a country—converting arable fields and vineyards into pasture-lands, pasture-lands into pine-forests, and pine-forests into regions of everlasting snow and glacier. This vertical relief of continents and islands depends, as already noticed, mainly on their lithological or rocky structure, on the intensity and continuance of the volcanic forces to which they have been subjected, and on the amount of waste and degradation they may have subsequently undergone. Thus, during the slow oscillations of the earth's crust, there are few tracts of the existing land that have not been more than once under the waters of the ocean; hence the amount of denuding, smoothing, and rounding of their reliefs. There are also few tracts that have not been subjected to a recurrence of volcanic activity; and hence, in proportion, the

greater irregularity, abruptness, and variety of their surfaces. And even after elevation into permanent islands and continents, these surfaces are all less or more subjected to aqueous and atmospheric waste, which is slowly but irresistibly moulding them into newer outlines, according to the harder or softer nature of the rock materials that compose them. The relief of the land is thus a thing of slow but incessant fluctuation, affected by every uprise and depression of the earth's crust, by every volcanic outburst, and by every action of the aqueous and atmospheric forces that waste and wear down the exposed surfaces. So gradually, however, do these forces operate, that no appreciable change is produced for centuries; and thus we are led to associate ideas of permanency with what in reality is incessantly but infinitesimally changing.

NOTE, RECAPITULATORY AND EXPLANATORY.

The facts connected with the general configuration of the land have been so fully stated in the preceding chapter, that very little additional explanation is required. Relative position, contour, and relief, are alike influential in modifying the external conditions of a region; hence the importance of their accuracy in all geographical descriptions. Latitude and longitude determine the position; a sufficient number of similar observations fix the contour; and trigonometrical survey or barometrical observation (mercurial or aneroid) can define the relief or outline of elevation. Position and contour are readily shown on maps by actual outline; relief can be indicated by a scale of shading, or more accurately by a system of contouring, as shown in Plate I. (Cartography) of the 'Physical Atlas.' Thus, taking the shore-line, which is all on the same level, as the first contour, we may have similar lines taken at every 50 feet or every 100 feet of ascent, and these (when the observations are sufficiently numerous) will exhibit, with great accuracy, the risings and fallings of the surface configuration. Such a series of lines gives, as it were, the moulding or model of the surface, and a section of this model, *such*, will show the profile for that direction. Suppose, for example, with its contours taken at every 100 feet to be represented by fig. 1; then fig. 2 will show the absolute elevation in the line of section A B. The closer the lines of contour, the more rapid or steeper the

ascent, and the more widely apart they are, the flatter is the slope of uprise. It is by such sections that the profiles of the different



Contour and Profile.

continents are usually shown by geographers, as will be more fully illustrated when we come to treat of the mountains and tablelands in the succeeding chapters.

Should the student desire to enter more fully into the subject of position, contour, and relief, with their ultimate bearings on the features and characters of the respective continents, he will find more ample details in Guyot's 'Earth and Man;' in Mrs Somerville's 'Physical Geography;' and in several of the chapters of Humboldt's 'Cosmos.'

Geology enables Geography to account for the external characters of mountains, and to explain why some should be massive rounded in outline, others serrated, with splintery peaks and acles—some conical and dome-shaped, and others, again, terminated by crags, or sloping away in long, gentle declivities.

1. Understanding the general character and formation of mountainous elevations, we may explain that the term *mountain* is usually applied to heights of more than 2000 feet—all beneath that height being regarded as *hills*, and those of still minor elevation as *hillocks*. A *mountain-chain* or *mountain-range* is a series of elevations having their bases in contact, and their axes or lines of elevation continuous, over a considerable extent of country—the Grampians, Urals, or Andes; a *group* consists of several ranges more or less connected; and a *system*, of several groups that evidently belong to the same set of geologic operations. Mountain-summits are distinguished by such terms as *cones*, when actually tapering to a point, as in volcanoes; *domes*, when more massive and rounded; *peaks*, when abrupt and insulated; and by the French word *aiguilles*, or *needles*, when still more pointed, splintery, and detached. The terms *undulating*, *serrated*, *rugged*, and the like, applied to their outlines or profiles, are so familiar in everyday language, as to require no special explanation. Mountain-sides consist of *slopes*, *terraces*, *escarpments*, and *precipices*, or of a combination of these; and these outlines depend chiefly on their geological structure, and partly on the amount of waste and degradation to which they have been subjected. In general, mountain-ridges have a long, gentle declivity on one side, and a short and abrupt one on the other; and where this occurs, the longer declivity is spoken of as the *slope*, and the shorter one as the *counter-slope*. This slope and counter-slope is equivalent to what is known in Britain as "*crag and tail*,"—most of our isolated hills presenting a bold precipitous front to the west or north-west, and a long slope or tail to the east or south-east—a configuration the obvious result of denuding currents, as the land gradually uprose from the waters during the pleistocene epoch. The depressions and narrow valleys which occasionally intersect mountain-chains are known as *defiles* and *passes*; and these, offering, as they often do, the only means of transit across mountain-barriers, have ever been objects of political and commercial importance. Some of the most celebrated deeds recorded in history are associated with these passes, and modern engineering is still in search of the easy gradients and facilities.

[We have said that the outlines of mountains depend chiefly on the geological structure, and partly, also, on the amount of waste and degradation.]

dation to which they have been subjected. It is in this manner that hills composed of hard basalts and greenstones, alternating with soft tufas or stratified rocks, assume *terraced* declivities; that extinct volcanic hills, like those of Auvergne, put on a *crateriform* aspect; that those largely composed of hard massive strata—as limestone, conglomerates, and sandstones—present a *tabular* appearance; and that mountains capped and flanked by crystalline schists are *serrated* with peaks and pinnacles.]

57. With these explanations, the principal MOUNTAIN-SYSTEMS, whose direction and extent will be best seen on reference to the Atlas, may be here enumerated—the student remembering that there is much in this arrangement that is arbitrary, or, at all events, not sufficiently established by actual observation. Thus, in EUROPE, geographers usually distinguish the *British system*, comprising the Grampians, Cheviot, Cumbrian, Cambrian, and Hibernian ranges; the *Iberian* or Spanish, embracing the Pyrenees, the Cantabrian Mountains, the Sierra Morena, Sierra Nevada, and the sierras of the central table-land; the *Sardo-Corsican*, consisting of the mountainous range of Sardinia and Corsica; the *Alpine*, including the Alps proper, Apennines, Carpathians, Balkan, and Hellenic ranges; the *Scandinavian*, or mountain plateaux of Norway and Sweden; the *Sarmatian*, or central high-ground of Russia; the *Uralian*, and *Caucasian*. In ASIA we have the *Western system*, comprising the Taurus, Anti-Taurus, Lebanon, Armenian, and Elburz ranges; the *South-eastern system*, embracing the Hindoo Koosh, the Himalaya, and the mountains of Bir-mah, Siam, and Cochin-China; the *Eastern system*, comprising the Kuen-lun, the Pe-ling, Yun-ling, Kihan-shan, In-shan, and other Chinese ranges; and the *North-eastern system*, extending from the Bolor Tagh in the centre of the continent to Behring Strait, and comprehending the Thian-shan, the Altai, Yablonoi, and Stan-novoi ranges. In AFRICA may be enumerated the *Atlas system*; the *Guinea system*, embracing the Kong and Cameroon Mountains; and, so far as is known, the *Eastern system*, comprehending such as the Quotlamba, Lupata, and other contiguous ranges. In NORTH AMERICA, the *Pacific system*, embracing the great range of the Mexican Cordilleras and the Rocky Mountains, on the west of the continent; and the *Atlantic* or *Appalachian system* (Alleghanies, &c.) on the east. In SOUTH AMERICA there is the giant system of the *Andes* in the west, the *Brazilian system* in the east, and the system of *Parimè* between the rivers Amazon and Orinoco in the north. Of AUSTRALIA and its mountain-chains we know too little as yet to enable us to arrange them into groups or systems, though one main ridge, extending along the eastern coast from Torres Strait on the north to the extreme point of Tasmania on the south, would seem to indicate a sameness and continu-

ity of geological upheaval. Besides the above, other minor systems have been named; but enough has been indicated to lead the student to the appreciation of the fact that the principal mountain-chains may be arranged in groups or systems that have arisen apparently from the same set of geological causes acting more or less continuously along the line or direction of their elevation.

[Touching the general distribution of mountains, it has been aptly remarked by Sir John Herschel that, "In the New World we find a continuity of a vast and extremely precipitous line of very elevated mountains, running from the Arctic Ocean almost to the extremity of Patagonia (a distance of 8280 statute miles), skirting along the western coast of that immense continent, closely following all its flexures in the southern half, and in the northern opening out somewhat more, it is true, but still preserving the same general character of a lofty, mountainous, western border to a vast expanse of eastern lowlands; and, throughout the whole of this border, we perceive a most distinct and unmistakable tendency to a system of double or triple ridges, nearly or exactly parallel, not here and there for short distances, but extending for hundreds of miles in succession, and resumed again and again when interrupted. In the Old World, on the other hand, we find no single, well-defined, continuous chain running throughout, much less following the coast-line, but a broad belt of mountainous country traversing the whole mass of land in a general direction, and carried through the heart of the continents, from the extremity of Europe and North Africa across to the western shores of the Pacific. In the European portion of this system, linear prolongation, except in the Pyrenees, is very far from distinctly indicated. On the contrary, divarication and embranchment are there the dominant features, as they are especially so in the north-western region of Asia; and it requires some determination in tracing connections to follow out a leading line through the Pyrenees, the higher Alps, the Caucasus, and the mountains of Elbrouz, through the Hindu Koh, up to the great system of Asiatic mountains which enclose the plateau of Thibet. Neither is the principle of parallel association carried out with anything like the same precision and sequence in the old as in the new continent. Along the Caucasian and Elbrouz range, and as far as the termination of the Hindu Koh, this principle is pretty clearly maintained; but from the point in Little Thibet where this last-mentioned system forks out into the two great chains of the Himalaya and Kuen Lun which enclose the table-land of Thibet proper, a greater degree of confusion and interlacement prevails, and beyond the termination of these ranges in Assam and on the Chinese frontier, the mountain-system of China and south-western Asia spreads out like an immense fan, in some of whose ranges a high degree of parallelism is preserved among contiguous members, while in others the branching character prevails quite as conspicuously."]

58. As mountain-systems exercise very decided influences on the natural history of the globe, and as they generally appear in ranges consisting either of one central chain with branches or spurs running off at right angles, or of several chains running less or more parallel to each other, various theories have been advanced to account for their upheaval, their parallelism, and their geographical connections. Thus, as their central masses generally consist of igneous rocks (compare Geological Map of Europe with Map of Mountain systems), which have been protruded from below, and as this pr

and since these and other facts along the line of least resistance in the crust of the mountain areas. What is the necessary cause of these 'tectonic' movements according to Elie de Beaumont, the French geologist, these vast mountain ranges occupy a portion of a great circle of the Earth's surface, and these ranges are easily made in his conception has a law there; and he shows that the mountain-belt of the same age are parallel to one another even when in opposite hemispheres. Professor Hopkins of Cambridge, treating the subject from a strictly mathematical point of view, has also shown that when the upheaving force acts in a single point, the lines of upheaval must radiate from that point; hence lofty central mountains with diverging spurs. He further shows that when the upheaving force acts uniformly over a wide area, the lines of greatest tension or upheaval must be in the direction either of the length or of the breadth of the area, and that, if the crust yields in more places than one, the fissures would necessarily be parallel. Of course this uniformity of system has been considerably obscured, if not modified, by subsequent geological changes; and it must also be remembered that, whatever may give the initial direction to a mountain-range, its subsequent increase is ever more a matter of accumulation than of upheaval.

European Systems.

As accepting such generalisations as initiatory steps towards the explanation of one of the most important problems connected with the history of our planet, we may now advert to the character of the mountain chains or ranges of which the preceding systems are respectively composed. Under the *British system* are embraced the Northern or Ross-shire range, the Grampians, the Cheviots, the Cumbrian or Cumberland mountains, the Cambrian or Wales, the Devonian, and the Hibernian or Irish, all having been in times a north-west and north-east strike, and all belonging to the earliest or primary geological periods. Their geological structure—large granitic masses flanked and capped by the crystalline schists—confers on them considerable boldness and diversity of outline, though their minor elevation prevents that massive grandeur and regularity so often displayed by loftier ranges. None of them rise to the height of perpetual congelation (about 11,000 feet for the centre of the British Islands); but in an insular position such as that they occupy, their cold, heath-covered summits exercise a decided influence alike on the climate and natural productions. Arranging them in

tabular order, with their culminating heights or points of highest elevation, they appear as follows:—

Northern or Ross-shire range, Ben Attow, .	4000 feet.
Grampians, Ben Nevis,	4368 "
Cheviots,	2741 "
Pennine chain,	2911 "
Cumbrian or Cumberland range, Scaw Fell, .	3166 "
Cambrian or Welsh mountains, Snowdon, .	3571 "
Devonian range,	2077 "
Hibernian mountains, M'Gillicuddy's Reeks, .	3410 "

60. The *Iberian or Hesperian system* embraces the Pyrenees, Cantabrian Mountains, Mountains of Toledo, Sierra Morena, Sierra Nevada, and other associated elevations that give character to the rocky table-land and peninsula of Spain. Less ancient than the British system, but loftier in their altitude and more extensive in their ranges, they exercise a still more decided influence on the external condition of their region. Ranging chiefly in an east and west direction, and upheaving rocks of primary and secondary formation, rising, in many parts, above the line of perpetual snow (which ascends from 8000 feet in the Pyrenees to 11,000 feet in the Sierra Nevada), and being intersected by numerous deep defiles and narrow valleys, they create great diversity of scenery, climate, and production, and are of themselves the frequent storehouses of the minerals and metals. Arranged in tabular form, with their culminating points, they are as follows:—

Pyrenees, Maladetta,	11,168 feet.
Cantabrian Mountains, S. Gredos,	10,552 "
Mountains of Toledo, S. Guadalupe,	5,110 "
Sierra Morena, Aracena,	5,550 "
Sierra Nevada, Mulhacen,	11,687 "

61. The *Sardo-Corsican system*, as its name implies, is confined to the islands of Sardinia and Corsica, and extends from Cape Jeulada in the former, to Cape Corso, in the latter. It is a high, rugged, and irregular range, attaining its culminating point in Monte Rotondo, in Corsica, which rises to the height of 8767 feet—an elevation closely bordering on the line of perpetual snow, which in that latitude ascends to 9000 feet. In its geological bearings it is evidently connected with the Alpine development, and ought, properly speaking, to be regarded as a mere outlier of that gigantic system.

62. Under the *Alpine system* are usually comprehended the whole of those extensive and lofty mountains which, from Switzerland as a centre, ramify in ranges more or less persistent, and confer on southern Europe one of its most marked and peculiar

Western Alps, Mount Pelvoux, . . .	14,108 feet.
Eastern Alps, Mount Blanc, . . .	15,744 "
Gallo-Francia, Mount Mollecon, . . .	6,588 "
Apennines, Mount Etna, . . .	10,874 "
Slavic range, Mount Kom, . . .	9,000 "
Hellenic range, Olympus, . . .	9,749 "
Balkan range, Mount Athos, . . .	9,628 "
Carpathians, Butschetje, . . .	7,528 "

63. The *Scandinavian system*, as the name implies, embraces the whole of the mountainous highland of Norway and Sweden, and extends in a north-eastern direction from the Naze to the North Cape, a distance of 1160 miles. It consists of a series of plateaux, high open fields, rather than of a continuous mountain-ridge. These elevations narrowing from a breadth of 200 miles in the south to 60 or 40 in the north, and being distinguished as the Langedangar or Langedal in the south, the Dovrefeld in the middle, and the Kiølen Mountains in the north. Intersected by numerous ridges and gorges, the range presents a steep face and rugged coast-line of fiords and cliffs to the North Sea on the west, and a gradual slope to the shores of the Baltic on the east. A great portion of the range rises above the limit of perpetual snow (which extends from 2400 feet at the North Cape to 5000 feet in the Langedal), but beneath this limit the mountain-sides are covered with ragged forests of birch and pine. Geologically speaking, the whole system is of primary origin—granitic, crystalline, and siliceous rocks composing the mass, which is abundantly traversed by metalliferous veins of iron, copper, lead, zinc, and antimony. Although the general elevation of the irregular table-lands seldom exceeds 5000 feet, the culminating points rise to a considerable altitude; thus—

Langedal, Skegstol-tend, . . .	8670 feet.
Dovrefeld, Sneeshatten, . . .	7620 "
Kiølen, Sulitelma, . . .	6200 "
„ North Cape, . . .	1161 "

64. The *Sarmatian system* (from the ancient Sarmatia or Poland) is meant by geographers to embrace that extensive swell of country which stretches diagonally through Russia from the plain of Poland to the flanks of the Uralian Mountains, and which forms the great watershed of northern Europe, turning the waters of the Vistula, Duna, Dwina, and Petchora to the Baltic and White Seas; and those of the Volga, Don, and Dnieper to the Caspian and Black Sea. There are no mountains throughout its extent, the Valdai Hills attaining an elevation of only 1100 feet; and it is chiefly of geographical importance as a great and continuous watershed.

The first of these is the Orinoco, which rises in the north-west of the continent, and flows northwards to the Gulf of Venezuela. The second is the Amazon, which rises in the north-east of the continent, and flows northwards to the Atlantic Ocean. The third is the Rio Negro, which rises in the south-east of the continent, and flows southwards to the Atlantic Ocean. These three rivers are the principal sources of water for the continent, and their waters are used for a variety of purposes, including agriculture, industry, and domestic use.

The Orinoco is the largest of the three rivers, and its waters are used for a variety of purposes, including agriculture, industry, and domestic use. The Amazon is the second largest, and its waters are used for a variety of purposes, including agriculture, industry, and domestic use. The Rio Negro is the smallest of the three, but its waters are also used for a variety of purposes, including agriculture, industry, and domestic use.

25. In South America we are presented with three well-marked and distinctive river-plains — viz. those of the Orinoco, the Amazon, and the La Plata. The first is one of the lowest and most level tracts in the world, rising not more than 200 feet at the distance of 100 miles from the sea, and throughout that course marked by awanags, periodically overflowed grass-flats (llanos), and frequent forest growth. The llanos occupy an area of about 100,000 square miles, which in almost wholly is so densely covered with tall, solitary gum-trees, but shortly afterwards is so densely covered with tall, solitary gum-trees that it is known to the natives as the "sea of gum-trees".

snow-line, and though the table-land they support is on the whole bleak and humid, their own slopes are often intersected by valleys of great beauty and fertility. Closely connected with them, topographically as well as geologically, is the Lebanon range, which, proceeding transversely from the Taurus, stretches southward along the Syrian coast to Mount Hermon, 10,000 feet high, and thence through Palestine to the peninsula of Sinai, where Horeb, 8593 feet, and Sinai, 7497 feet, terminate the chain. In the northern portion of the chain the loftier heights are covered with perpetual snow, while the lower slopes are wooded and fertile; but in the southern portion, the mountains, though lower, are abrupt, rocky, and arid. Also intimately associated with the Taurus and Anti-Taurus, and in fact but prolongations of the same ranges, are the mountains of Armenia, which trend eastward in the Elburz, and southward into the Zugros and hills of Kurdistan. They form a series of broad-shouldered mountains, with lofty intervening valleys, and culminate in the steep-sided, snow-covered cone of Ararat, 17,210 feet high. The Elburz range—a continuation, as it were, of the Armenian and Taurus mountains—skirts the southern shores of the Caspian, where it attains, in the slumbering volcano of Demavend, an altitude of 21,000 feet, and thence stretches eastward, with less defined elevation, into the high grounds of Tartary and the chain of the Hindoo Koosh. This last-mentioned range, the Hindoo Koosh or Hindoo Koh, separates Afghanistan and the Punjaub from Independent Tartary, and forms the watershed between the Amoo and the Indus. Its maximum elevation is about 20,000 feet, and, trending eastward in broad massive ridges into the Kuen-lun and Himalayas, it may be regarded as the commencement of the great central system of the Asiatic continent. Such are the principal members of the *Western mountain-system* of Asia, which are all intimately connected with the first plateau stage of that continent. In the main, they run in east and west directions, though sending out several southern spurs, as the Lebanon, Kurdistan, and Beloochistan hills. They are largely of secondary and tertiary age; and though intersected by minor valleys, they fade away rather into high arid table-lands than alternate with river-plains of corresponding dimensions—those of the Euphrates and Jordan being the only alluvial plains of any importance. The following are among the highest points of the system:—

Hindoo Koosh, summit,	.	.	.	20,232 feet.
Elburz range, Demavend,	.	.	.	21,500 "
Armenian mountains, Ararat,	.	.	.	17,210 "
Anti-Taurus, Agriçsch,	.	.	.	13,197 "

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lands, the *landes* of France, the *dunes* of Holland and the *fens* of England, and the *swamps* of Florida, are on the increase, and in process of time assume a flat or surface.

There are plains and valleys at considerable elevations, and are again scarcely raised above the overflow of the tides, and are several areas of the land-surface depressed even below the general level of the ocean. Laying aside some tracts of marshy land which are said to sink beneath the sea-level, the most remarkable of these ascertained depressions are the Aralo-Caspian basin, and the trough of the Dead Sea. The former of which are situated the Caspian and Aral seas, is a vast area of 162,000 square miles in extent, and all completely below the ocean—the surface of the Caspian, the lowest part of the cavity, being actually 83 feet beneath the level of the Black Sea. The latter, though a mere trough in comparison with the former, is still more remarkable for its depression, the Dead Sea being no less than 1312 feet lower than the Mediterranean, from which it is 50 miles distant, and separated by a mountain-range of the Lebanon. Whatever the origin of these cavities—whether by subsidence of their areas or by upbuilding of barriers that cut them off from the general ocean—it is probable that were their river-supplies not fully counterbalanced by evaporation they would in process of time become filled with water, and their surplus find an outlet by the lowest course to the sea. The Aral and Caspian would be discharged into the Persian Gulf over the low steppes of the Volga and Don; while the waters of the Dead Sea would find their way to the Gulf of Arabia, in the Red Sea, with which, at some former period, it was evidently connected by the dry stony valleys or “wadies” that now lie between.

Origin and Characteristics of Lowlands.

99. As the terrestrial *highlands*—the mountains and tablelands of the world—owe their origin chiefly to the elevatory forces of vulcanicity, so the *lowlands*—the plains, deserts, and valleys—depend for their formation mainly on the levelling effects of water. Many of the larger plains are but old sea-beds—shoals and bars and marine plateaux—that have been gradually elevated above the waters; others are the accumulated silts of shallow seas and bays, while some, again, have been formed by the slow alluvial increment of river-deltas. Of the minor plains and valleys, many

basins of the Yang-tse-Kiang and Hoang-Ho, the system at the same time diverges, fan-like, into the Yun-ling chain, between Tibet and China ; the Nan-ling, between the basins of the Yang-tse-Kiang and Canton River ; and the conjunct chains of the Ala-shan, In-shan, and Khingan, that trend in a north-easterly course, and form the southern wall of the great Mongolian desert. Altogether, the Eastern system is little known to geographers, either as regards the altitude of its mountain-chains, their physical features, their geological structure, or the minerals and metals they contain.

70. Commencing, in like manner, with the central knot of the Bolor, and stretching away in broad, more or less parallel, lines to Kamtchatka and Behring Strait, occurs the *Northern system of Asia*, flanked by the arid deserts of Tartary and Mongolia on the south, and descending by gradual stages to the great plain of Siberia on the north. The system embraces the Thian-shan or Celestial Mountains, ranging in an easterly direction for nearly 1400 miles, ascending in greater portion above the line of perpetual snow, but comparatively free from glaciers on account of the dryness of the air, and exhibiting throughout a number of volcanic cones, some of which, like Pe-shan and Ho-tscheou, are still active at elevations of more than 10,000 feet. In north-easterly continuation we have next the Altai Mountains, comprising several parallel ridges (the Tang-nu, Ulam-gom, and Dzungari), the Daurian, Yablonoi, and other little known ranges—all rising between Siberia and Mongolia, and separating the basin of the Amoor from those of the Yenesei and Lena. These closely associated ranges are said to have a mean elevation of from 5000 to 8000 feet ; embrace several active and many extinct volcanoes ; rise high in numerous points above the snow-line, which is there about 6000 feet ; and culminate occasionally in peaks of 10,000 and 11,000 feet. Like other clustering ridges, the Altai and Daurian Mountains enclose a number of lakes, which find an outlet by narrow cross valleys, and terrace by terrace downwards to the larger rivers of Siberia. Still northward and eastward, but ramifying more irregularly, occur the Aldau, Stannovoi, and other chains that terminate in the volcanic system of Kamtchatka. These ranges are for the most part covered with snow (the snow-line sinking to 4500 and 4000 feet in Eastern Siberia), and contain numerous volcanic cones which, like Schiwelutch, 10,548 feet, and Klientschewska, 15,955 feet, are still in active eruption. Indeed, the whole system is more or less volcanic—active cones, dormant craters, hot springs, gas-springs, and other kindred phenomena, marking the broad line of mountainous elevation that extends from Demavend on the Caspian to Klientschewska in Kamtchatka.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters we have endeavoured to present a view of the superficial features of the land, as composed of mountains and table-lands, of plains and valleys, and the relation of each to each other in the scheme of Physical Geography. It is the geological law that regulates the successive upheavals and submergence of large tracts of the earth's crust, we see the arrangement of the present continents the more violent effects of the earthquake and volcano in producing abrupt and enormous irregularities, and the more gradual efforts of air and water moulding into uniformity of surface its plains and valleys. It is the nature of the vulcanism acting from within, we see it exerts itself along certain lines and in definite centres, these lines and centres give rise to mountain chains and groups, these again give contour and configuration to the terrestrial surface. In the Old World, as already stated, the main axis of elevation is from east to west; hence the greatest length of the continent in this direction, and hence, also, the determination of the courses of the great rivers and river-plains in northerly and southerly courses from the axis. In the New World, again, the main line of elevation is south to north; hence, also, the corresponding direction of the continent and the opposite courses of the principal rivers. It is with the main continental masses so with the minor spurs and peninsulas—their direction of greatest length being invariably regulated by the direction of their hills. Geology thus becomes the obvious groundwork of geography; and on reference to the Geological Map of Europe, for instance, it will be seen that all the glacial, trappean, and volcanic outbursts are but expressions, in other terms, for the extent and directions of the mountains of that continent. As the great plains are but the undisturbed portions of the continents, they will naturally take the same main direction as the mountain-ranges; just as the table-lands which are raised by the mountains will be situated among their groups or along their axes. On the other hand, the rivers, obeying the laws of descent from the opposite sides of these axes, will have their valleys and dales running less or more in cross-courses, thus giving additional features of diversity to the land.

Mountains and table-lands, plains and valleys, are thus but counterparts of each other; and rugged and inhospitable as the former may seem, the latter would be but thirsty deserts were it not for the clouds and rains, the streams and rivers, that are gen-

but under the *Guinea system* are usually embraced the Kong and Cameroon Mountains—the former rising between the Gulf of Guinea and the Niger, and generally averaging from 1200 to 3000 feet (Soracte, 1278, and Mount Ramel, 3200 feet); and the latter stretching eastward and unknown into the centre of the continent, and rising in many points to elevations of 4000, 6000, 9000, and even 13,000 feet. From the Cameroons, southward to Damara Land, the seaboard rises in terraces, backed by several ranges, of which very little is known; though the Campleda chain is said to attain an elevation of from 12,000 to 14,000 feet; the Mozamba, from 8000 to 10,000 feet; and the Omatako Berg, from 8000 to 9000 feet.

74. In Southern Africa the surface is occupied by a series of sandstone plateaux, resting on, and intersected by, granitic rocks, rather than characterised by a series of well-defined mountain-chains—these flats (*karoo*s) rising step by step, from south to north, at elevations of 2000, 4000, and 6000 feet above the sea-level. The steps of this ascent consist of rocky walls and flat-topped mountains, ranging in an east and west direction, and intersected by narrow defiles (*kloofs*), which form the only means of passage from terrace to terrace; and these mountains (*bergs*) may, for the sake of reference, be denominated the *Cape system*. It consists, 1st, of the Zwellendam range, about 20 miles inland from the Cape coast, and stretching for nearly 200 miles in length, and attaining, in Table Mountain, an elevation of 3816 feet; 2d, the Zwarte or Black range, about 30 miles further north, and separated from the Zwellendam by the Kannaland Karoo; and, 3d, the northern chain, consisting of the Roggeveld, Nieuwveld, Winter Mountains, Sneeuwveld, Wittebergen, and other contiguous ranges, separated from the Zwarte hills by the great Karoo, and attaining heights of 4000, 6000, and even 10,000 feet, as in the Compass Berg in the Sneeuwveld or Snowy range.

75. From this point begins what may be termed the *Eastern system*, consisting of the Drakenberg or Quotlamba Mountains (10,000 feet), the Lupata Mountains (8000 or 10,000 feet), and other ranges that hold northward in parallel lines and increasing altitudes towards the equator, where several of the higher peaks (Kenia and Kilmandjaro, 17,000 and 20,000 feet) are said to be covered with perpetual snow. From the equator, in the direction of Abyssinia, would seem to extend high table-lands of 7000 or 8000 feet, which merge themselves, in all likelihood, into the highlands of upper Ethiopia, and form the great gathering-grounds of the Nile.

VIII.

THE WATER—ITS OCEANS AND SEAS.

Their Area and Configuration.

101. HAVING considered the various conditions of the Land—its configuration, highlands, and lowlands—we now turn to the use of the Water, as exhibited in its oceans and seas, their areas, depths, composition, tides, currents, and kindred phenomena. And here it may be observed of WATER, which forms so important an element in the constitution of the globe, that, chemically speaking, it is the *protoxide of hydrogen*, consisting of two volumes of hydrogen and one of oxygen, or of eight parts of oxygen to one of hydrogen by weight—88.9 oxygen and 11.1 hydrogen. When pure and at ordinary temperature, it is fluid and colourless, without taste or smell, colourless in small quantities, but in large masses of a peculiar bluish-green or blue. The specific gravity of pure or distilled water, at 62° Fahr., is assumed at 1.000, and is taken as the standard of gravity for all other bodies; but sea-water varies, according to locality and the depth from which it is taken, from 1.027 to 1.029. When heated to the temperature of 212° Fahr. at the level of the sea, and under the ordinary pressure of the atmosphere, water boils, and is converted into steam; and this *boiling point* (as it is termed) becomes less as we ascend above the sea-level. In other words, as the pressure of the atmosphere becomes less, *ebullition*, or the phenomenon of boiling, takes place sooner, and this so uniformly that it is taken, like the barometer, as a measure of ascent or altitude. The effects of boiling at the sea-level, and boiling at an elevation of 12,000 feet, are, however, two very different things: what would be cooked by the former heat, might remain unchanged for hours under the influence of the latter. At 40° Fahr. water is at its minimum volume, expanding as it rises above that temperature, till it is wholly converted into vapour, and also, as it falls below it, till at 32° for

rated from each other by the narrow cross-valley of the Hudson. In length the system is nearly 2000 miles, has an average breadth of 100 or 130 miles ; and though its mean altitude is only about 2500 feet, it yet ascends in Mount Washington in New Hampshire to 6652 feet, in Black Mount between Tennessee and Carolina to 6420 feet, and in Mount Katahdin in Maine to 5360 feet. In the northern section of the system, the ridges of the Notre Dame, the Green, White and Adirondack Mountains are more or less irregular and interrupted ; but in the southern, the Alleghanies consist of several closely parallel chains of great continuity, though frequently cut across by ravines and river-courses. Geologically, the system consists chiefly of the older or palæozoic rocks, flanked on both sides by an extensive development of carboniferous strata ; and its eastern slopes comprise some of the finest and most diversified country in the American Union. Separated from the preceding system by the valley of the St Lawrence, but still trending in the same general direction to the northern shores of Labrador, occur the Wotschish and Mealy Mountains, which, though seldom exceeding 1400 or 1600 feet in height, are yet, from their boreal position, for the most part covered with perpetual snow. The following are the culminating points of this Eastern or Atlantic system :—

Mount Washington, New Hampshire,	. . .	6652 feet.
Black Mount, Carolina,	. . .	6420 "
White Mountains, Massachusetts,	. . .	6230 "
Mount Adams, Alleghanies,	. . .	5960 "
Mount Jefferson, Alleghanies,	. . .	5860 "
High Peak, Adirondack Mountains,	. . .	5467 "
Katahdin, Maine,	. . .	5360 "
Notre Dame, Lower Canada,	. . .	3768 "
Kaatskill, New York,	. . .	3454 "

78. Interiorly and beyond these eastern ranges the country is one immense plain till we come to the *Western or Pacific system*, which, under the familiar name of the Rocky Mountains, stretches in several more or less connected ranges from the Isthmus of Panama to the shores of the Arctic Ocean. This extensive system, which after all is but the northern prolongation of the great backbone of the New World, consists of two main ranges—the Pacific or Oceanic, skirting the western seaboard from Cape Lucas in California to Cape Elizabeth in Russian America—and the Rocky Mountains proper, extending in double and sometimes in treble chains from Panama to the Arctic shores. The former of these ranges forms the watershed between the Pacific on the west and the Colorado, Columbia, and Colville on the east. Though continuous as one great range, it consists of several members, such as the Sierra S. Lucia and Sierra Nevada in California, whose highest

and comprehensive. Or, looking upon the waters that southwards from the extreme points of Africa, Australia, and America, as one great united mass, the term *Southern* will often be found to be convenient, and not inappro-

Taking the Atlantic Ocean as extending from the arctic to antarctic circle, its length is upwards of 9000 miles; its breadth varies from 900 to 4000 miles, being only 900 between Iceland and Greenland, 1700 between Sierra Leone and Brazil, 1100 between Marocco and Florida; and its computed area about 25,000,000 square miles. This vast expanse is little indented by islands; in its northern section it is irregular in shape, and throws several important branches into the land; but in the southern its form is regular, and its shores continuous. Towards the north it is partly enclosed by the rocky coasts of Iceland, Ireland, and Norway; but towards the south it is quite open, and merges broadly into the Antarctic Ocean. The leading branches are Baffin and Hudson Bays, the Gulf of St Lawrence, the Gulf of Fundy, Gulf of Mexico, and the Caribbean Sea, on the west American side; and on the east or Old World side, the North Atlantic Sea, English Channel, Bay of Biscay, the Mediterranean and the Gulf of Guineæ. All, or nearly all, of these recesses are in the northern division of the Atlantic; hence the greater interest of this section to the geographer, naturalist, and navigator. Of the minor seas or ramifications belonging to the Atlantic of which are ice-locked for a considerable portion of the year, and thus encumbered by reefs and shoals, the most important, socially and vitally, is the Mediterranean, whose shores formed the chief nurseries of civilisation and commerce, and whose waters are the highway of communication, not merely between the continents—Europe, Asia, and Africa—that encircle its shores, but between these and every other portion of the globe. “The political and social events which have occurred on the shores of this remarkable part of the ocean,” says Admiral Smyth, “are connected with the history of almost every country in the world, but independently of its classical and historical associations the Mediterranean still confers invaluable advantages upon its numerous occupiers of its coasts, and through them on the inhabitants of the surrounding continents. It is, moreover, the great centre of intercourse between the nations of Europe, Asia, and Africa, although it appears as if it had been destined to keep them apart. Beautifully diversified with islands, and bounded by every variety of soil, its products are proportionally varied. Cut off from its communication with the Atlantic, it facilitates

Mount St Helens, Cascade Range,	15,750 feet.
Mount Hood, Do.	15,000 "
Mount Jefferson, Do.	15,000 "
Toluca, V., Mexico,	15,168 "
Agua, V., Guatemala,	15,000 "
Tsashiti, Sierra Nevada,	14,000 "
Mount Fairweather, Sea Alps,	14,783 "
Amilpas, Guatemala,	13,160 "
Fremont's Peak, Wind River Mountains,	13,568 "
Colima, V., Mexico,	13,000 "
Atitlan, V., Guatemala,	12,500 "
Mount Regnier, Cascade Range,	12,320 "
Mount Taylor, Rocky Mountains,	12,256 "
Wrangell's V., Russian America,	12,064 "

[Referring to the Californian earthquakes of 1856, Dr Traak (in 'Silliman's Journal' for 1857) remarks, that "along the coast of Mexico and Central America to the south of California, from all the records that are obtainable, there appears to have been a much greater exemption from those phenomena than has been usual in former years. This seems to have been the fact also throughout the Pacific, Oceanic, and most of the continental islands along the coast of China; while to the north and north-west beyond the 55th parallel, both volcanic and earthquake phenomena appear to have been more violent than usual. This has been observable for the most part in the neighbourhood of the Aleutian Archipelago, along the north-east coast of Japan, and in the British and Russian possessions of North America on the Pacific, and islands of the Ochotsk Sea."]

79. In South America the pre-eminent system is that of the *Andes*, which extends along the Pacific seaboard from Tierra del Fuego on the south to the Isthmus of Panama on the north—there connecting itself with the onward prolongation of the Rocky Mountains. As a mountain-range the Andes form one of the most definite and persistent on the globe—skirting in unbroken ridges the entire Pacific shore for nearly 4500 miles in length, and varying in breadth from 40 to 350 miles. In some places the range consists of a single ridge; in other places of two or more ridges supporting lofty but narrow plateaux; and in general it presents a steep slope towards the Pacific, from which it is distant from 20 to 80 miles, while towards the east it descends by gradual stages into the broad plains of the Orinocco, Amazon, and La Plata. According to Humboldt, the mean elevation of the Andes is 11,830 feet, and the extent of surface covered by their bases not less than 531,000 square geographical miles. Geologically, the system is composed of granites, greenstones, and porphyries, flanked by metamorphic schists and palæozoic strata, but exhibits throughout a greater number of active craters than any other mountain-chain, and as a consequence is largely crowned and covered, especially on its western slopes, by vast accumulations of lava, scoriæ, and other volcanic products. Though presenting one continuous axis, the range consists of several members known

Europe, Asia, and America, which remarkably conform to the parallel of 72° , and having an area roughly estimated at 4,000,000 square miles. It penetrates northern Europe by the White Sea and Sea of Kara, and northern Asia by the Gulf of Obi and a small inlet, and northward from these shores seems interrupted by comparatively few islands. The northern shores of America, however, present so many islands and ice-locked inlets, that it has, up to the present moment, been impossible to determine whether land or water continues northward and surrounds the pole. The Antarctic Ocean, on the other hand, is open on all sides to the Pacific, Atlantic, and Indian Oceans, which thus possibly merge themselves into the great Southern Ocean. So far as navigators have ventured to approach the southern pole, various islands and shores have been observed which would favour the idea of a circumpolar continent; but whether land, sea, or ice-bound archipelago occupies the immediate region of the pole, is likely long to remain an undetermined problem. Altogether, the Antarctic is a cold, boisterous, and unapproachable ocean—its ice extending 10° nearer the equator than that of the Arctic, and offering few of those inducements that have stimulated repeated research in the Northern Ocean.

109. Such are the areas occupied by the waters of the ocean—areas and subdivisions which are not only necessary to intelligible description, but which are marked in reality by different conditions and characteristics in nature. Position on the globe decides their temperature; area and configuration determine their tides and currents; and the sum of these physical conditions regulates the nature and distribution of their plants and animals. Any change, therefore, either in position, area, or configuration, would be attended by a corresponding change of conditions, and any such alteration would affect all the consequences, physical and vital, that depend on external conditions. As they exist, the North and South Atlantic, situated under different latitudes, enjoy different temperatures; while the north, by virtue of its greater irregularity of form, and numerous ramifications into the land, exhibits a much more varied display of vegetable and animal life. The same also holds good of the North and South Pacific, with these important modifications, that the North Pacific, compared with the North Atlantic, is almost excluded from Arctic influences, while the numerous islands of the South Pacific occasion conditions, physical and vital, peculiarly its own. The Indian Ocean, surrounded on three sides by land, and situated, for the most part, in the torrid zone, presents peculiarities

of the Northern; that the greatest saltness takes place parallels of 22° north and 17° south, or in the courses de-winds, which absorb and carry off an excess of evaporation towards the equator, where it descends in freshening and that from these limits of maximum saltness there is progressive diminution towards either pole.

in the southern hemisphere, says Captain Maury, there is more sea water than in the northern. But the hydrometer indicates that the sea of the former is saltier and heavier than the water of the latter; and man's reasoning faculties suggest, in explanation of this difference of saltness, or specific gravity, is owing to the evaporation in the southern half, excess of precipitation in the northern half, of our planet. "When water passes, at 212° Fahr., into steam, it absorbs 1000° of heat, which becomes insensible to the thermometer; and, conversely, when steam is condensed into water, it gives out 1000° of latent heat, which thus becomes free, and affects both the thermometer and the senses. Hence steam of 212° Fahr. will, in condensing, give out heat five and a half times its own weight of water from the boiling point."—*M'Culloch*. Now there is in the southern hemisphere a larger water-surface exposed to the sun than there is in the northern hemisphere, and this excess of heat is employed in lifting up and evaporating (rendering saltier) that broad surface, in transporting it across the tropics, and conveying it to extra-tropical northern latitudes, where the vapour is condensed to replenish our fountains, and where this heat is set free to mitigate the severity of northern climates.]

though communicating freely (by currents and counter-currents) with the ocean, the majority of inland seas are less salt than the ocean, in consequence of the influx of rivers into their interior areas; but some, like the Red Sea, receiving no water, and not subjected to active evaporation, have their saltness in excess. As a general rule, inland seas receiving numerous rivers, and from their situation subjected to little evaporation, are fresher than the ocean (*e.g.*, the Baltic); while others also receiving rivers, but subjected to a more active evaporation (as the Caspian), will have their saltness somewhat in excess. The saltness of the sea is pretty uniform at great depths, but near the surface, owing to the admixture of rain, river, and ice-water, it is not quite so salt; and this freshness will increase, according to proximity to the mouths of the entering rivers. It has also been ascertained that water from the surface is less aerated than that from depths, and the difference may be one-hundredth of the volume of water.

Another noticeable property of salt water is, that it is heavier than fresh water, if we may so speak, or colder than fresh water—the latter, as is well known, at 32°, while sea-water is not converted into ice until the thermometer sinks to 28½° Fahr. It is likewise less vapourising than fresh water—that is, a given extent of salt-water surface

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ciated with the mountain-systems, most of these systems not rising in narrow ridges from low-lying plains, but towering above broad elevated regions which seem to be formed and supported by their bases. Thus, on turning to the map of Asia, it will be seen that all the great rivers flow north, south, east, and west from the central region, which consists in reality of a succession of lofty terraces or plateaux. First we have the table-land of Iran or Persia (including large tracts of Beloochistan, Afghanistan, and Bokhara) rising from 2300 to 3500 feet above the sea-level, upwards of 300,000 square miles in area, and presenting throughout a riverless, parched, and desolate region; next in altitude, the great sandy and rainless desert of Gobi, rising from 4000 to 6000 feet, and occupying an area of nearly 400,000 square miles; then, rising on either side of this, towards the centre, the plateaux of Dzungaria and Upper Tartary, less arid and more varied in surface; and, lastly, the still loftier plateau of Tibet, the highest inhabited region in the world, with an elevation of from 11,000 to 15,000 feet, and an area of 166,000 square miles. Besides these great central uplands there are in Asia the lateral and more isolated plateaux of the Deccan, rising from 1600 to 2000 feet in Hyderabad, to 4000 feet and upwards in Mysore; of Arabia, the sandy and arid, varying from 3000 to 6000 feet high, and spreading over an area of more than 700,000 square miles; of Armenia, 7000 feet high, supported by the Taurus and Anti-Taurus, and extending from the Dardanelles to the Caspian; and, lastly, that of Ust Not, between the Caspian and Aral Seas. With the exception of the Deccan and the mountain-platforms of Armenia and Tibet, the whole of these table-lands, from Arabia on the west to Gobi or Shamo (sand-desert) on the east, belong to one great belt of arid and rainless country, sandy and shingly in soil, desert in character, and evidently belonging to the same geological age and formation. Alluding to the ethnological effects of these long desert ranges of high land, it has been remarked by Humboldt, that "they separate the ancient and long-civilised races of Tibet and Hindostan from the rude nations of Northern Asia. They have also exerted a manifold influence on the changing destinies of mankind. They have inclined the population southward, impeded the intercourse of nations more than the Himalayas or the Snowy Mountains of Siringanur and Gorka, and placed permanent limits to the progress of civilisation and refinement in a northerly direction."

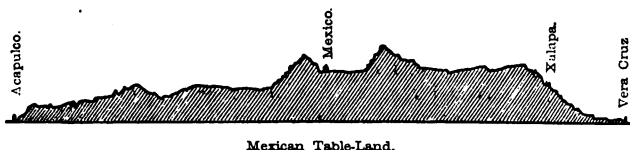
84. In Europe, less elevated and more broken up by seas, we have a smaller development of table-lands, and these generally of limited area, and in the southern or higher division of the continent. The most notable is that of Castile, in Spain, having an elevation

of from 2000 to 2300 feet, and traversed by hilly ridges (sierras) that give great irregularity and diversity to its surface. There is next the less defined upland of Switzerland, from 3000 to 4000 feet in elevation; and, trending north-eastward in the same direction, the lower plateaux of Bavaria and Bohemia, the latter having an elevation of only 900 or 950 feet above the sea. The so-called plateaux of Avergne and of the Scandinavian and Balkhan chains may be regarded as mere mountain-flats, too limited in extent to possess any physical feature, or to exercise any influence distinct from those of their associated ranges. In like manner, what has been termed by some geographers "the Carpathian-Uralian plateau"—that flat open region that stretches between the Carpathians and Urals—may be looked upon merely as the southern belt of the great European plain, more elevated, no doubt, than the rest, but still exhibiting more of the characters of the plain than of the upland or plateau.

85. Of Africa we have too scanty information as yet to speak with certainty respecting the plateaux and mountains that may rise within its interior; but we know that much of the Sahara or Great Desert is of a flat elevated nature (from 1500 to 2000 and 4000 feet), and that inland from the coasts of Congo and Loango the country assumes the character of a lofty table-land. There is also the plateau of Abyssinia (Amhara or Axum), from 7000 to 8000 feet above the sea-level, supported and traversed by several clustering mountain-ridges which form the gathering-grounds of the Atbara and Blue Nile; and, lastly, the *karoos*, or terrace-plains of Southern Africa (already noticed in par. 74) rising stage by stage towards the interior to an elevation of 2000 feet, carpeted with grass during the rainy season, and parched and barren for the rest of the year.

86. In the New World the great superficial contrast is less between mountain and table-land, or plain and elevated upland, than between the gigantic mountain barrier that walls the Pacific from one extremity of the continent to the other, and the low broad plains that stretch eastward from its base towards the Atlantic. Nevertheless, in South America, the chain of the Andes presents several table-flats of vast elevation—the most remarkable being that of Bolivia, a great table-land 120,000 square miles in extent, rising from 11,000 to 12,500 feet above the sea, and early the seat of a busy and wealthy civilisation. Much also of the interior of Brazil partakes of the table-land character, having a mean elevation of 3000 feet, and traversed by the sierras (par. 80) that give feature to that fertile and tropical country. In North America, from the Russian territory on the north to Mexico on the south, there occur a series of elevated

uplands, upborne, as it were, by the parallel ranges of the Rocky Mountains. One of the most remarkable of these plateaux is that comprising the highlands of Oregon and the saline desert or inland basin of Utah, whose elevation is from 4000 to 5000 feet, and the waters of which, having no outlet, form a series of salt lakes, one of which (Utah) is of considerable extent, and almost saturated with salt. Desert and inhospitable as this upland tract undoubtedly is (Colonel Fremont found the water covered with ice every night during the month of August), it seems destined to be the great overland highway between the Atlantic and Pacific States of North America—the ascents on either side being so prolonged and gradual as to be accessible, it is reported, even to railway construction. The most decided of the American table-lands, however, is that of Mexico, not more remarkable for its elevation than for its persistent



extent. "On the eastern and western coasts," says M. Balbi, "are low countries, from which, on journeying into the interior, you immediately begin to ascend, climbing to all appearance a succession of lofty mountains. But the whole country is thus in fact raised into the air from 4000 to 6000 and 8000 feet. The conformation of the country has most important moral and physical results; for while it gives to the table-land, on which the population is chiefly concentrated, a mild, temperate, and healthy climate, unknown in the burning and deadly tracts of low country into which a day's journey may carry the traveller, it also shuts out the former from an easy communication with the sea, and thus deprives it of a ready access to a market for its agricultural productions." As with the Mexican table-land, so in fact with all others of any decided elevation. A distant island in the ocean is not more separated from its contiguous continent, or more strongly marked by its own physical peculiarities, than a high mountain-walled tract raised several thousand feet into the atmosphere is characterised by a climate and vegetable and animal productions unknown in the regions that surround it.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter the attention of the student has been directed to the more elevated portions of the land, as consisting of mountains and table-lands. These mountains have been arranged by geographers into *chains* and *ranges*; and these ranges, again, into *groups* and *systems* that occupy the same contiguous area, and apparently belong to the same series of geological operations. The continuity of mountain-chains has been observed from the earliest times, and hence the antiquity of the names by which many of them are distinguished; but their classification into groups and systems is of recent date, and liable to correction and amendment as clearer and more correct views are obtained respecting the forces on which their formation and elevation depend. There is no doubt that to the volcanic forces acting in lines or axial directions more or less continuous, we owe our mountain chains and ranges; and to a repetition of such ranges in directions having some degree of parallelism or connection, we give the name of group or system; but what the law that determines the course of volcanic activity, and regulates its shifting in time from area to area, science can do little more than merely conjecture. That it is the purely dynamical, depending partly on lines of least resistance, partly on the relations of the terraqueous crust to the internal igneous mass, and partly, it may be, to some unknown successional change in the motions of the globe itself, is the most that our present knowledge can suggest—a suggestion that will require long-continued research and exact calculation to carry into the domain of reliable theory.

But whatever the law, its modes of manifestation have been the same throughout all the geological epochs; and we can trace in the structure of the old palæozoic and mesozoic mountains upheavals, accumulations, and disruptions precisely analogous to those that characterise the volcanic hills of the present day. The lines and centres of activity are changed (see Map of Volcanic Action, page 97), and the products of accumulation exhibit a newer aspect, but this is all. We see in the vast cincture of vulcanism that girdles the shores of the Pacific—the Andes, Mexican, and Rocky Mountains on the one side, and the Kamtchatkan peninsula, Japan, Philippine, and Sunda Isles on the other—a mountain-system in elaboration as vast and continuous as any yet described by geography. And when we cast our eyes over the numerous centres of activity which stud the bosom of the same ocean, we

warmer according to the position they occupy and the from whence they proceed. The surface temperature of Mexico, for example, is several degrees warmer (86° have been named) than the main Atlantic under the latitude; the waters of the Gulf Stream are also several higher in a large portion of its course than those through it flows; while the Arctic Current, on the other hand, is really colder. "It may be regarded as a general rule," says authority, "that the temperature of all inland seas, at great represents nearly the mean temperature of the earth in itudes where they are situated; whilst in the ocean, the perature at the bottom, in every latitude, is produced by ad currents setting eternally from the polar regions, and maintain the water at an almost constant temperature—its maximum density, 39° Fahr."

Besides the preceding conditions of saltness, density, depth, mperature, there are also those of *colour* and *luminosity*, adverted to by navigators and geographers. In small ies water is generally regarded as colourless, but that of an assumes different hues, and this altogether independent colours of the sky which may be mirrored on its surface. in the open ocean, shallow water is indicated by a *green* different degrees, while profound depths are characterised *indigo blue*. Whether this arises from the greater density mass, or from some peculiarity of its saline constitution, is st satisfactorily known; but the fact remains, and "sea-waves" and "dark-blue oceans" are something more than poetic fancies. Of course, in some localities there may be ntal or even permanent discolorations, arising from the ace of river-water, from peculiarity of bottom, or from the ace of countless myriads of vegetable and animal organisms; the application of such terms as Red, Black, White, Yellow, and Vermilion to certain seas and areas of the ocean. In al, however, the ocean water is clear and limpid, and, under rable circumstances, objects are reported to have been seen depth of 300 and 400 feet, or about half the distance to the sun's light is supposed to penetrate into the abyss of

3. The phenomenon of luminosity or phosphorescence is l al, perhaps, and seems to depend in a great degree on locali n of the year, and state of the weather. Luminous anim and creatures of various kinds appear to be the proxima e of the phenomenon, which becomes more apparent in still nights, and where the surface of the water is disturbed by troke of an oar, or the friction of a passing keel.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been directed to the main natural divisions of the ocean ; and to the composition, density, depth, temperature, colour, luminosity, and other physical characteristics of their waters. The divisions of the ocean into Pacific, Atlantic, Indian, Arctic, and Antarctic areas, are sufficient for the ordinary purposes of description ; and the nomenclature of their various ramifications after some discoverer, position, adjacent country, colour, or other peculiarity, has been long established in general geography. Their further subdivision into *zones*, *belts*, *regions*, and the like, comes under the consideration of Climatology rather than of Hydrography ; and the technicalities (bays, gulfs, straits, creeks, &c.) by which their minor sections are distinguished, have been already noticed in par. 42. Their dimensions are matters merely of measurement and calculation ; their composition, depth, temperature, and the like, are subjects for experiment and observation.

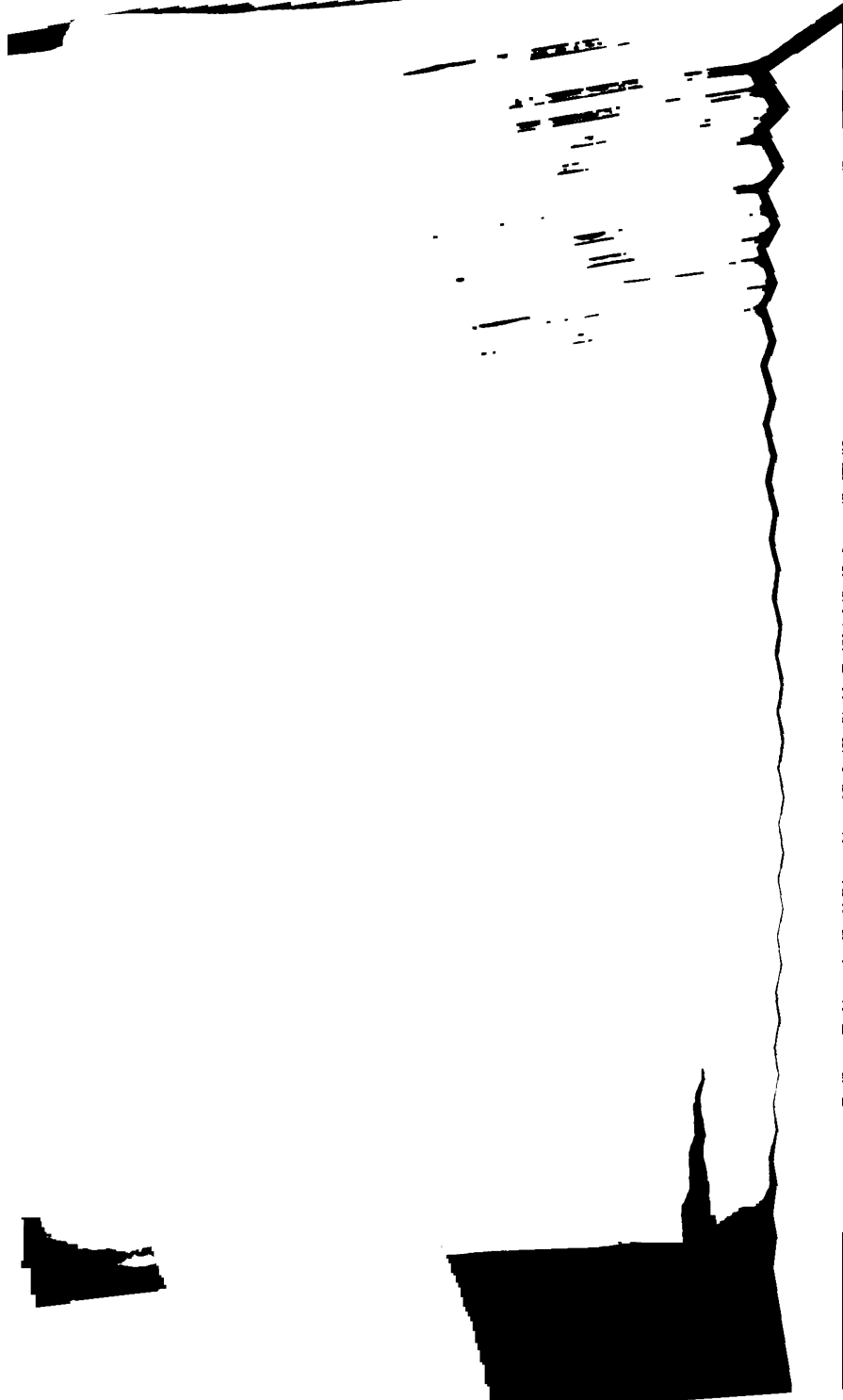
Occupying different positions on the earth's surface, and having different configurations, the oceans and seas, properly so called, are necessarily characterised by different physical and vital conditions. The Pacific, almost shut out from the influences of the Arctic Ocean, is in a different condition from the Atlantic, which communicates freely with the north ; while the Indian Ocean, encircled on three sides by land, and lying largely in the torrid zone, presents external conditions differing widely from either. All three open broadly to the great Southern Ocean, from which they receive the primary impulse of their tides and currents ; but while the Indian and Atlantic are deep and free, the Pacific is largely obstructed by reefs and islands. It should also be borne in mind that the main oceans, like the great continents, lie meridionally, or at right angles to the equator, and are thus prevented, by the intervention of the land, from receiving in their winds, tides, and currents, the normal effect of the earth's daily rotation.

Though differing slightly in different areas, the composition of sea-water is, on the whole, very equable, and $3\frac{1}{2}$ per cent of saline ingredients may be set down as the general average. Along the courses of the trade-winds, in circumscribed seas, and other similar areas subjected to active evaporation, this percentage may be slightly increased ; while in others it may be correspondingly decreased by periodical rainfalls, by the melting of polar ice, or by the influx of large and rapid rivers. The average density of sea-

water, as compared with pure water at 62° Fahr., is 1.0275; and this density, corresponding as it does with an average saltiness of $3\frac{1}{2}$ per cent, will decrease where the water is fresher and increase where it becomes saltier than the general average. This saltiness and density renders the ocean less vaporisable than fresh water, and also keeps it longer from freezing—the freezing point of fresh water being 32° Fahr., while that of sea-water is 28 $\frac{1}{2}$ °. This composition is all-essential to the wants of its plants and animals; and though the rivers are incessantly carrying in fresh accessions of saline matter, the equilibrium is ever maintained by these wants as well as by the chemical interchanges that take place among its sediments.

The average depth of the ocean is estimated at 4 miles, and reliable soundings have been taken at nearly 5 miles; but, as a large portion is much under the general average, it is highly probable that some of its recesses may sink to the depth of 8 or 10 miles. So far as we know, the ocean-bed has its deeps and shoals, its pits and precipices, its troughs and ridges, very much like the surface of the dry land. In fact, it is but the submerged surface of former lands; and no better conception can be formed of its irregularities than by standing on some lofty mountain, and supposing the hills and valleys, the glens and gorges, the plains and plateaux that lie beneath, to be covered with water. A knowledge of these depths—or rather of the shoals and irregularities of the ocean-bed—is of vast importance in geography, at the same time that it is all-essential to navigation. The safety of the commerce of the civilised world depends upon correct chartography; these deeps and shallows determine the direction of currents, and inset and velocity of tides; and marine life is visibly regulated both in its dispersion and numerical amount by depth and mineral conditions of sea-bottom.

The surface temperature of the ocean varies of course with the latitude, being highest at the equator, and gradually decreasing towards either pole. In the torrid zone temperatures varying from 78° to 88° have been noted, and from these maxima it declines, stage by stage, to the perpetual ice of the polar regions. The mean temperature has been ascertained to be 39 $\frac{1}{2}$ ° Fahr., or nearly that of water at its maximum density; and between the 56th and 57th parallels (S. lat.) this temperature has been found to be uniform from the surface to the greatest depths. Towards the poles, however, the surface becomes colder, and the mean of 39 $\frac{1}{2}$ ° in the 70th parallel is not found till at the depth of 750 fathoms; while towards the equator the surface grows warmer, and the mean of 39 $\frac{1}{2}$ ° is not reached till at the depth of 1200 fathoms.



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1. THE STATE OF NEW YORK
 2. IN SENATE CHAMBER
 3. AT ALBANY THIS 15TH DAY OF APRIL 1901
 4. REPORT OF THE COMMISSIONERS OF THE LAND OFFICE
 5. FOR THE YEAR 1900
 6. ALBANY 1901
 7. PRINTED BY THE STATE OF NEW YORK
 8. PRINTING OFFICE
 9. ALBANY

which they travel. Thus it has been
 ry that a wave 100 feet in breadth
 travels at the rate of about 15 miles
 road and in water 1000 feet deep, at the
 another, 10,000 feet in breadth and in
 will sweep forward with a velocity of not
 hour. This relation between the breadth
 f progress, and the depth of the water in
 en embodied by Mr Airy in the following

<i>Breadth of the Wave in Feet.</i>					
100	1000	10,000	100,000	1,000,000	10,000,000
<i>Corresponding Velocity of Wave per Second in Feet.</i>					
5.667	5.671	5.671	5.671	5.671	5.671
16.883	17.921	17.933	17.933	17.933	17.933
22.264	53.300	56.672	56.710	56.710	56.710
22.264	71.543	168.380	179.210	179.210	179.330
22.264	71.543	226.260	533.900	566.720	567.100
22.264	71.543	226.260	715.430	1688.300	1793.300

ce with which a wave strikes against any opposing
 as, in like manner, upon its bulk and velocity; and
 huge waves this impact is enormous. From experi-
 at lighthouses and breakwaters, their effective pres-
 is estimated as high as 6000 lb. per square foot: and
 y to observe the breaches occasionally made in sea-
 the distance to which blocks of stone, several tons in
 ve been hurled forward, to be convinced of their great
 power. Of course the force with which a wave simply
 not to be altogether estimated by its propulsive power,
 ances submerged in water lose a certain portion of their
 which greatly facilitates their displacement and transport.

Tides—their Origin and Influence.

the next, and perhaps the most important and persistent
 movements, is that of the TIDES—a term applied
 ic rising and falling of the waters, occasioned chie
 action of the moon, but partly also by that of the s
 ce to the universal law that "every particle in nat
 ery other particle with a force inversely as the squa
 nce," the earth is attracted by the sun and moon, bu
 e latter, in proportion to its greater proximity. Land

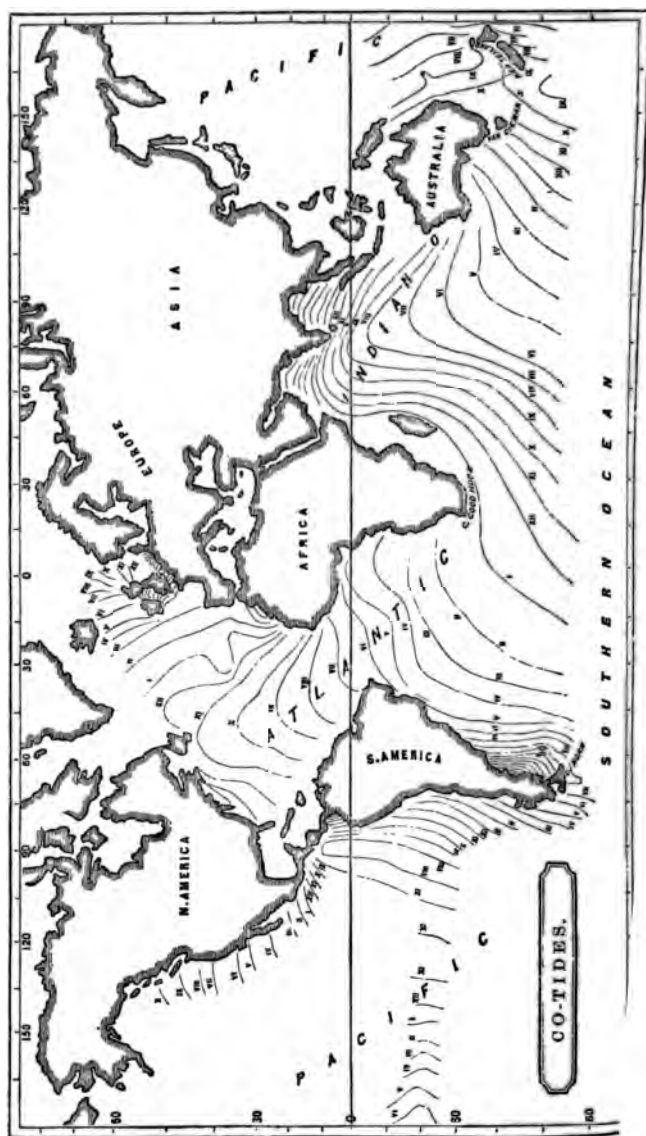
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the sun, exerting a simultaneous attraction either along with or against that of the moon, creates an alternate maximum and minimum of flow. Thus, when the sun is at S and S' his attraction is combined with that of the moon, and a higher tide is the result. When at S the darkened side of the moon will necessarily be towards the earth, and it is new moon; and when at S' the illuminated face of the moon will be towards the earth, and it is full moon; so that the higher or *spring-tides* take place alternately at new and full moon. On the other hand, when the moon is 90° from the sun's place (that is, when she is in her first and last quarters, or half moon), his attraction, being exerted at right angles, counteracts that of the moon, and the result is the lower or *neap-tides*—the proportion of spring to neap being as 138 to 62, or nearly as 7 to 3. The *height* and *time* of the tides thus vary with the moon's age; and this being known, their recurrence and culmination at any given spot can be calculated with the greatest exactitude. The greatest tides occur, of course, when the luminaries are nearest and pass most vertically to the place of observation; and as each tide has only about six hours to *flow*, and about six hours to *ebb*, the highest must necessarily be the *swiftest*, and the lowest the *slowest*.

130. Such, in general terms, is the theory of the tides; and had the surface of the globe been entirely covered with water, the tidal wave would have been regular and continuous from meridian to meridian, and, as a consequence, highest in the region of the equator, and gradually falling away towards either pole. But the continuity of the ocean being interrupted by land, and this land lying in a great measure meridionally, as well as being irregular in outline, and consisting in many parts of islands, the course of the tidal flow is obstructed, and deflected into various courses. Under the present arrangement of sea and land, these courses are, however, sufficiently persistent; and thus their directions, times, velocities, and heights, can be determined with accuracy for the purposes of navigation. The Southern Ocean, encircling the globe, and being comparatively uninterrupted by land, may be regarded as the area in which the tidal wave receives its great primary impulse. It is thence carried forward, deflecting itself northward into the Indian, Atlantic, and Pacific Oceans, where, uniting with the minor tide-waves generated in these expanses, it flows, rises, and subdivides, according to outline of the coasts, the depth of water, and the obstructive islands.

131. Notwithstanding the complications arising from these causes, there is still great regularity in the bi-diurnal flow and ebb.



of the tides; and by noting the times at which the same high-water reaches different parts of the coast, a series of lines connecting these points may be laid down so as to indicate the course of the tidal wave with great precision. Such a series of lines are termed *co-tidal lines*, or lines of simultaneous tide, and mark the progress of the summit of high-water from its origin in the Southern Ocean to its remotest ramifications in northern waters. We say northern waters, for though the primary and normal direction of the tidal wave is from east to west, in obedience to the apparent course of the sun and moon, yet, on entering the troughs of the Indian and Atlantic Oceans, it is compelled to assume a northerly course in accordance with the configuration of these seas. Thus the new or full moon high-water that passes Van Diemen's Land every morning at twelve, takes twelve hours to reach Ceylon, and thirteen to reach the Cape of Good Hope; in another twelve hours it has passed up the Atlantic, and arrived at Newfoundland; at the end of the third twelve it has rounded the north of Scotland, and is opposite to Aberdeen; at the fourth twelve, or at midnight of the second day, it is opposite the mouth of the Thames; and it is "not till the morning of the third day that this wave fills the channel of the Thames, and wafts the merchandise of the world to the quays of the port of London." (See Map of *Co-tidal Lines*.)

132. The tides, we have said, may be regarded as taking their rise in the uninterrupted expanse of the Southern Ocean. As the wave proceeds westward, it is deflected northward broadly into the Indian Ocean, rapidly and deeply into the larger channel of the Atlantic, and slowly and feebly into the Pacific, where its course is obstructed by numerous islands and coral-reefs. The *velocity of the tidal wave* depends primarily on the conformation and depth of the ocean—proceeding with the greatest rapidity where the ocean is freest and deepest. As the co-tidal lines are laid down at hourly distances, they afford a pretty correct estimate of the tidal velocity—the wider the lines (that is, the greater the distance travelled over in one hour) the greater the speed, and the closer the lines the slower the rate of progress. In the free depths of the Southern Ocean this velocity may equal 1000 miles per hour, while in restricted seas like the North Sea the rate is scarcely a twentieth of that amount. As the tidal wave differs from a wave in not being a mere undulation, but a wave of translation, its *height* in any sea will depend mainly on the configuration of the shore, the form of bottom, and the direction in which it is propelled. In the open expanse of the Southern Ocean the wave rarely exceeds five or six feet, and in the Indian and Atlantic Oceans perhaps eight or ten; but in bays and gulfs opening

broadly to its course, and narrowing towards their interior recesses, such as the Bay of Bengal, our own Bristol Channel, and the American Bay of Fundy, it may rise to 20, 30, or, under favourable circumstances, even to 50 or 60 feet in height. And where such seas terminate in river-estuaries, the wave, still converging, forms a high head or wall of water, termed a *Bore*, which ascends the river with sudden and destructive impetuosity. Such are the tidal waves of the Tsien-tung, which are said to extend across the river 50 feet high, and ascend with a velocity of 25 miles per hour, of the St. Lawrence 20 and 25 feet high, of the Garonne 10 and 12 feet, the Severn 9 feet, the Amazon 12 and 13 feet, and other rivers whose gradually narrowing estuaries are exposed to the concentrated influence of the tidal wave. On the other hand, inland seas and gulfs whose openings are narrow, and lie transversely to the course of the tidal wave as the Mediterranean and Baltic, experience little or no rise, and are next to tideless. Not only is the primary wave that sets up the Atlantic excluded from such seas, but their own areas are too limited to admit of the formation of any perceptible tide-wave of their own; and thus, for all practical purposes, strictly inland seas and lakes may be considered as tideless.

133. Unlike an ordinary wind-wave, whose undulations are imperceptible at the depth of 1000 or 1200 feet, and unable to disturb from its repose the smallest grain of sand, the progressive motion of the tide-wave affects the whole mass of waters from the surface down to their greatest depths. The mechanical effects of the wind-waves are felt chiefly along the shore-line in their battering, wearing, and abrading action; the tide-waves, on the other hand, act more like currents, which, in their ebb and flow, are ever transferring, arranging, and re-assorting the sediments of the ocean. The wind-wave merely breaks upon the bars of rivers and renders their navigation dangerous; the tidal wave, by its influx, fills the river-channel and renders it navigable, and by its efflux, scours out impurities, and carries them forward into the general reservoir of the ocean. The wind-wave may be stilled, driven from one coast it impinges on another; or the wave from one direction may counteract that from another: but the ebb and flow of the tidal wave is regular and incessant, and in its direction, time, height, velocity, and power, will continue the same while sea and land remain undisturbed in their present relations.

Currents—their Causes and Functions.

134. We now proceed to what are termed the CURRENTS of the ocean—movements which, like great rivers, are ever transferring the waters from one region to another. They form, in fact, the circulatory medium by which the ocean is maintained in a state of equilibrium, and depend primarily upon the unequal temperatures and densities of different zones of the ocean and the unequal evaporation sustained by these zones; and secondarily upon the rotation of the earth, which modifies the directions imparted by these primary causes. Wherever we have waters of different temperatures, or, what is the same thing, of different densities, there the lighter will ascend and the heavier descend; and wherever a deficiency takes place through evaporation, there the waters will flow in from the adjacent parts to make up the deficiency. But difference of density may also arise from different degrees of saltness, and wherever the saltier water subsides and flows off as an under-current to some fresher region, there at the same time will the fresher and lighter flow in from above to restore the equilibrium. Understanding these facts, and bearing in mind that the continuity of the ocean is interrupted by continents and islands, reefs and shoals, and further disturbed by winds and tides, it will readily be seen why its currents should assume different characters and courses. In fact, the currents and counter-currents of the ocean are extremely complicated; and though the courses and causes of some of the main streams are intelligible enough, there remains very much to be done in this department of Hydrography.

[On the equilibrium or equalisation of the waters of the ocean in temperature, density, saltness, &c., it has been appropriately remarked by Captain Maury, that "water, while its capacities for heat are scarcely exceeded by those of any other substance, is one of the most complete of non-conductors. Heat does not permeate water as it does iron, for instance, or other good conductors. Heat the top of an iron plate, and the bottom becomes warm; but heat the top of a sheet of water, as in a pool or basin, and that at the bottom remains cool. The heat passes through iron by conduction, but to get through water it requires to be conveyed by a motion, which in fluids we call currents. Therefore the study of the climates of the sea involves a knowledge of its currents, both cold and warm. They are the channels through which the harmonies of old ocean are preserved. Hence, in studying the system of oceanic circulation, we set with the very simple assumption—that from whatever part of the ocean current is found to run, to the same part a current of equal volume is bound to return; for upon this principle is based the whole system of currents and counter-currents of the air as well as of the water."]

135. It is usual to arrange the ascertained currents into con-

stant, *periodical*, and *variable*—the constant being those arising from the combined influences of unequal temperatures and densities in the waters of the ocean, the rotation of the earth, and the trade-winds; the periodical by the tides, the monsoons, and the sea and land breezes in tropical countries; and the variable, such as may be produced by local peculiarities in the tides and winds, the melting of ice in polar regions, and other similar causes. It is also customary to speak of *drift currents* and *deep-sea currents*—the former due to the long-continued agency of the wind, and only affecting the waters to a trifling depth, the latter arising from the great primary causes of temperature and density above alluded to, and extending their influence hundreds of fathoms beneath the surface. In like manner, it may be useful to note the distinction between a *marine*, or upper current, and a *sub-marine*, or under-current; between a *current* flowing one way, and a *counter-current* coming from an opposite direction; and between the mode of naming winds and water-currents—the former being named after the direction *from* which they blow, as a “west wind” (that is, one blowing from the west), and the latter after the direction *to* which they are flowing, as an “easterly current,” that is, one flowing towards the east.

136. The constant and deep-sea currents being the more important, it is to these that we would mainly, and in the first place, direct attention. As already mentioned, the heat of the torrid zone, by warming the equatorial waters, renders them lighter, and occasions a greater evaporation there than in any other region; and as a consequence, the waters of the polar regions, being heavier, set in as an under-current towards the equator to restore the equilibrium. It must be noted, however, that the Atlantic and Pacific being land-locked, as it were, to the north, the principal exchange of cold and warm water takes place towards the Antarctic Ocean, into which both merge widely and without interruption. Here then we have two great primary currents setting in from north and south respectively; but as they proceed towards the equator they come stage by stage into latitudes where the earth's circumference rotates with greater velocity, and as they cannot at once partake of this increased momentum, they fall behind, as it were, and gradually assume a westerly course, in which their velocity is augmented by the influence of the trade-winds. They become, in fact, a combined equatorial current, where, growing warmer and warmer, they ascend to the surface, and are partly evaporated and partly flow over in warmer and lighter surface-currents northwards and southwards to either pole, again to become colder and again to find their way to the equator in incessant circulation.

From these four primary flows—the two from the poles towards the equator, and the two from the equator towards the poles—arises the great circulatory system of the ocean, which is modified and broken up into a number of minor currents by configuration of coast, form of bottom, unequal reception of heat by different areas, the influx of rivers, and other kindred causes. These various currents, having different directions, volumes, velocities, and temperatures, will be better understood, perhaps, by being arranged under the three great oceans—Atlantic, Indian, and Pacific—in which they respectively occur.

137. The principal and better-known currents of the Atlantic are the Equatorial, the Guiana, the Brazil, the Gulf Stream, the Guinea, and the Arctic. Besides these there are some minor drifts and branches, the courses of which will be better understood by reference to the Map (p. 140) than by any amount of description. The *Equatorial*, as the name implies, manifests itself chiefly in the region of the equator, and flows across the ocean from the African towards the American continent. When more than half-way across it shows a tendency to bifurcate into a north-west branch and a south-west branch, and this tendency increases till within 300 or 400 miles of Cape St Roque, when it fairly divides—sending one main stream northwards by the coasts of Guiana into the Caribbean Sea; and another, somewhat feebler, southwards along the shores of Brazil. The length of the Equatorial Current, from the coasts of Africa to the Caribbean Sea, is about 4000 miles; its breadth at its commencement 160, and where it divides 450 miles; its velocity is from 20 to 60 miles a-day; and its average temperature about 75° Fahr., or from 4° to 6° under that of the ocean through which it flows. Its southern, or *Brazil* branch, flows at a distance of about 250 miles from the coast (the intermediate space being occupied by variable currents), and at the rate of 25 miles per day; a rate, however, that is sensibly diminished by the cross stream from the Plata, and which gradually declines till the current ultimately dies away in the Strait of Magellan. The north-west branch of the Equatorial, spreading out as it proceeds and gradually diminishing in speed, ultimately merges into the drift of the north-east trade-winds; while the *Guiana* section proceeds unimpeded to make the circuit of the Caribbean Sea and the Gulf of Mexico.

138. As they make the circuit of the Caribbean Sea and the Gulf of Mexico, these western branches of the Equatorial Current acquire more heat, a greater degree of saltness, and that intense blue colour so characteristic of briny waters. With these new ac-

[illegible]

quisitions they leave the Mexican Gulf, and, pressing through the narrow channel of Florida, become the celebrated *Gulf Stream*—of all the Atlantic currents the most wonderful in its character and the most important in its results. Doubling the Cape of Florida, this Gulf Stream (that is, stream from the Gulf of Mexico) flows north-east in a line almost parallel to the American coast; touches the southern borders of the banks of Newfoundland; and thence, with increasing width and diffusion, proceeds across the Atlantic, till, in the region of the Azores, it spreads out into two great branches—one curving southwards towards the equator, and the other flowing northwards, impinging in its course against the western coasts of Europe, and ultimately losing itself in the waters of the Arctic Ocean. The length of this great ocean-river from its commencement to the Azores is 3000 miles, and its greatest breadth about 120 miles. When it leaves the Strait of Florida its velocity is about 4 miles an hour; off Cape Hatteras, in North Carolina, it is reduced to 3 miles; on the Newfoundland banks it is further reduced to $1\frac{1}{2}$ miles; and this gradual abatement of force continues with its diffusion across the Atlantic. A similar decrease takes place in its temperature, the maximum of which in the Strait of Florida is 86° , or 9° above that of the ocean in the same latitude. Off Newfoundland, in winter, it is said to be from 25° to 30° above the water through which it flows; in mid-ocean, from 8° to 10° ; nor is the heat wholly lost when it impinges against the shores of western Europe. The Gulf Stream is thus, in reality, a great thermal ocean-river, incessantly flowing from warmer to colder regions, diffusing warmth and moisture along its course, and tempering the climates of countries that lie within its influence. Compressed, as it were, at its commencement between two areas of colder water, its deep-blue warm current rises in convexity above the surrounding ocean; but as it proceeds it cools, becomes diffused, assumes the ordinary level, and partakes of the greener hue of northern waters. It sets a limit to the southward flow and chilling influences of the Arctic iceberg, that melts away in its warm stream, and becomes at the same time the great natural barrier between the Life of the Northern and Southern Atlantic.

139. The Equatorial Current, flowing westward from Africa to the Gulf of Mexico, and the Gulf Stream, flowing from that gulf eastward to the Azores, and thence curving southwards, produce a great whirl, as it were, in the Atlantic, in the centre of which there is the still water of the *Sargasso*, or *Grassy Sea*. This area, so called from the vast accumulation of the *Sargassum bacciferum* and other floating sea-weeds, swarms with a Life, vegetable and animal, peculiarly its own, and presents one of the

most remarkable features in the geography of the Atlantic.—Following the southward flow from the Azores, and the south-easterly flow from the south coast of Ireland, against which a minor current (*Rennel's*) from the Bay of Biscay impinges and recoils, there arises a new and increased stream, which holds onwards to the African continent. Of this current, the eastern portion sets in through the Strait of Gibraltar to the Mediterranean, while the western trends southward, and becomes the *North-African and Guinea Current*. This stream, from 150 to 180 miles broad, hugs closely the coast, and for a long part of its course flows in contact with, but counter to, the Equatorial Current, with whose waters it is supposed ultimately to mingle in the South Atlantic.

140. The next and last great current of the Atlantic to which our limits will permit us to advert, is the *Arctic*, or main cold-water stream from the north. Setting strongly down the eastern coast of Greenland, it partly doubles Cape Farewell, where, augmented by the Davis Strait Current, it holds southward to Newfoundland. Arriving at Newfoundland, it sends a branch through the Strait of Belle Isle to the St Lawrence, while the main portion continues its course till it meets the Gulf Stream. Here it divides, one portion flowing southward to the Caribbean Sea, which it enters as an under-current; the other, flowing south-west, forms the United States *Counter-Current*. "The Arctic Current thus replaces the warm water sent through the Gulf Stream, and modifies the climate of Central America and the Gulf of Mexico, which, but for this beautiful and benign system of aqueous circulation, would be one of the hottest and most pestilential in the world."

141. In the more limited and land-locked area of the Indian Ocean, the constant currents are few, and the periodical numerous and important. The *Equatorial* is less defined than in the Atlantic, and consists of a westward tendency of the tropical waters towards the coasts of Africa, where, divided by the large island of Madagascar, one branch sets down with considerable force, and forms the *Mozambique Current*; while another, broader but feebler, trends southward, again to be united with that from the Mozambique Channel. The combined stream, now from 90 to 100 miles broad, with a temperature 7° or 8° above that of the ocean, and with a velocity of 60 or 80 miles a-day, sets in towards the Cape of Good Hope, and constitutes the *Agulhas or Cape Current*. Of this current, one main branch, doubling the Cape, flows northward into the Atlantic as far as St Helena; where, meeting the Guinea Current, it is deflected westward,

and merges into the Equatorial of that ocean ; whereas another portion, obstructed by the Agulhas bank, is turned back, and, combining with the connecting flow from the Southern Ocean, constitutes the important *Counter-Current* of the Indian Ocean. We say "important" counter-current, for it flows along the direct route to Australia, and with a velocity (after leaving the Agulhas bank) of nearly 50 miles a-day—a motion which, though gradually declining, is still sensibly felt at more than midway between the Cape and Tasmania. North of the equator, the currents and surface-drifts of the Indian Ocean are regulated by the monsoons, and vary, of course, with the seasons ; while in the Red Sea, Arabian Sea, Persian Gulf, and Bay of Bengal, they set in and out with the local winds, and often change in a very complicated and capricious manner.

142. The currents of the Pacific are coextensive with its greater area, but are less decided in their courses in consequence of the numerous obstructions presented by its reefs and islands. They are altogether less known than those of the Atlantic and Indian Oceans, and their investigation is greatly complicated by the frequency of counter-currents, surface-drifts, and local gyrations. Being all but excluded from the Arctic Ocean, it is to the great interchange between the cold waters of the Antarctic and the warmer waters of the equator that we must look for the primary impulse of its currents. Beginning with the Antarctic, to which it opens broadly, we have first the *Drift Current* of that ocean setting in towards the north - north - east, then north - east, and lastly towards the east-north-east till it nears the coast of Chili, where it divides—sending one branch south along the coast to form the *Cape Horn Current*, and another northwards to form the *Peruvian Current*, so remarkable for its cold stream along a coast of torrid temperature. This Peruvian, Chili, or "Humboldt's Current" (as it is sometimes called, after its first investigator), has a temperature along more than 400 miles of its course 12° or 14° below that of the surrounding atmosphere, and 8° or 10° below that of the ocean through which it flows. As it holds on to the north it gradually becomes warmer and inclines to the west, till in 20° south latitude it turns fairly to the westward and merges into the great *Equatorial Current* of the Pacific. This vast current, occupying the entire torrid zone, and aided in its westerly flow by the trade-winds and the tidal wave, sweeps boldly across from South America on the one hand to the Indian Archipelago on the other. As it proceeds, it sends off a few minor streams to the north and south, which become *counter-currents*, but the main mass holds onward to the Indian Islands,

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

2. Once the problem is identified, the next step is to define the objectives and goals of the project. This helps to clarify what needs to be achieved and provides a clear direction for the team.

3. The third step is to develop a plan or strategy to address the problem. This involves breaking down the problem into smaller, manageable tasks and determining the resources needed to complete each task.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress regularly to ensure that the project is on track.

5. The final step is to evaluate the results of the project. This involves comparing the actual outcomes with the objectives and goals to determine the effectiveness of the project and identify areas for improvement.

[illegible]

Let me tell you that
I am not in the
Hall of the Moon's

revolution, and her position as regards the sun, there are two spring-tides and two neap-tides a-month. The moon being the nearer luminary, her attraction or tide-wave compared with that of the sun is as 100 to 38; and from this cause also the difference between spring-tide and neap-tide in any locality is as 7 to 3. Had our planet been covered by a uniform sheet of water, the flow of the great tidal wave would have proceeded with unvarying regularity in time, height, and velocity all round the globe; but owing to the interruption and conformation of the continents, the varying depths of sea, and similar irregularities, it differs in different areas; and yet in each of these areas its rise and fall are as unvarying as the rotation of the earth or the revolution of her satellite.

The currents of the ocean depend chiefly upon the unequal temperatures and densities of its different regions—the colder and warmer, the denser and lighter, the salter and fresher, incessantly tending to interchange and equilibrium. These currents are either constant, periodical, or variable—the constant depending on the primary and established relations of the earth; the periodical on monsoons, tides, and sea and land breezes which occur in certain seas at stated seasons; and the variable on local winds, melting of ice, river floods, and other similar contingencies.

To those who may wish to enter more fully into the consideration of the waves, tides, and currents of the ocean—their directions, volumes, velocities, and causes—we have again to recommend perusal of Captain Maury's 'Physical Geography of the Sea,' the only comprehensive, and at the same time popular, treatise that has appeared on the subject in the English language.

in mist and cloud, coming in contact with cold mountain-peaks, condensing into rain, and falling in torrents to augment the runnels and rivulets. From runnel to stream, from stream to river, the



Circulation of Water.

mass swells and hurries downward and onward to the great receptacle whence the light and filmy vapour originally arose, there to renew the same career, and perform analogous functions.

["Water," says the eloquent author of the 'Physical Geography of the Sea,' "is Nature's carrier. With its current it conveys heat away from the torrid zone, and ice from the frigid; or, bottling the caloric away in the vesicles of its vapour, it first makes it impalpable, and then conveys it by unknown paths to the most distant parts of the earth. The materials of which the coral builds the island, and the sea-conch its shell, are gathered by this restless leveller from mountains, rocks, and valleys in all latitudes. Some it washes down from the Mountains of the Moon, or out of the gold-fields of Australia, or from the mines of Potosi; others from the battle-fields of Europe, or from the marble quarries of ancient Greece and Rome. These materials, thus collected and carried over falls or down rapids, are transported from river to sea, and delivered by the obedient waters to each insect and every plant in the ocean at the right time and temperature, in proper form and in due quantity. Treating the rocks less gently, it grinds them into dust, or pounds them into sand, or rolls and rubs them until they are fashioned into pebbles, rubble, or boulders. The sand and shingle on the sea-shore are monuments of the abrading and triturating power of water. By water the soil has been brought down from the hills, and spread out into the valleys, plains, and fields for man's use. Saving the rocks on which the everlasting hills are established, everything on the surface of our planet seems to have been removed from its original foundation, and lodged in its present place by water. Protean in shape, benignant in office, water, whether fresh or salt, solid, fluid, or gaseous, is marvellous in its power."]

nd this may be occasioned by sudden droughts and rainfalls, by the expansion and escape of steam and gases, by the ebb and flow of tides, and other kindred causes.

150. Surface springs generally vary in temperature with the seasons: deep-seated ones, being beyond these influences, are equable at all times. It was stated in par. 17 that the earth's crust, at the depth of 80 or 90 feet, is unaffected by summer's heat or winter's cold; but that below this depth the temperature went on increasing at the rate of 1° Fahr. for every 60 feet of descent. Springs whose sources are above this invariable stratum will therefore fluctuate in temperature according to the season of the year; those that ascend from beneath it will gradually increase in heat—the deeper being the hotter. Of the latter we have instructive examples in the Artesian wells of France and other countries—those borings emitting water from 60° to 90° and upwards, and this strictly according to depth, and altogether independent of the nature of the strata through which they are carried. *Cold springs* generally flow from chilled mountain sources; *hot springs*, on the other hand, arise either from vast depths, or are situated in the neighbourhood of volcanic action. Thermal and hot springs (hot even beyond the boiling point of water, and accompanied by violent jets of steam) occur abundantly, and on a gigantic scale, in Iceland, the Azores, Central Asia, New Zealand, the Andes, and other volcanic regions; they occur also in Britain, the Pyrenees, Germany, Austria, and other countries far removed from any centre of volcanic activity. Like ordinary springs, hot springs are either perennial or intermittent—perennial, like those of southern France and the Pyrenees, that have flowed without abatement since the time of the Romans; and intermittent, like the Geysers (“roarers”) of Iceland and New Zealand.

151. The waters that percolate the earth being of different temperatures, and often containing carbonic acid and other gases, act chemically, less or more, on the rocks through which they pass. In this way they become *mineral springs*—that is, hold in solution various mineral ingredients, which are either deposited along their courses on land, or borne onward to the ocean. Some, for example, are saline, or contain salt; some chalybeate, or contain iron (*chalybs*, iron); some siliceous, or contain flint (*silex*); some calcareous, or contain lime (*calx*); while others give off sulphurous vapours, or are impregnated with the salts of various minerals and metals. Such are the sulphuretted waters of Harrogate, the brine springs of Cheshire, the borax springs of Tuscany, the travertine or lime-depositing waters of the Anio, the siliceous hot springs of Iceland and the Azores, and thousands of others that

by rainfalls), they are said to be *permanent*; but when arising solely from rainfalls, melting of snow, and the like, they are *temporary*, and often of short duration. Permanent streams are usually distinguished, according to their dimensions, as *rills*, *streamlets*, *brooks*, *rivulets*, &c. (each country, and even province of a country, having its own expressive term for such distinctions), and their currents form *ravines*, *glens*, *gorges*, *valleys*, and other descriptive excavations. Temporary streams, on the other hand, are little noticed save in regions subjected to periodical rains, their dry courses being known as *nullahs* in India, *wadies* in Arabia, *creeks* in Australia, and so on in other localities. Streams occur in all countries, but fewest and least, of course, in rainless latitudes. Their great headquarters are the slopes of mountain-chains and the outer margins of valleys, and there they impress on the country geographical features and geological relations peculiarly their own. Coursing down the mountain-sides with headlong speed, they form ravines, gorges, and waterfalls—their excavating power depending primarily upon their volume and velocity; and, secondarily, on the nature of the materials to be eroded. The aggregate amount of debris brought down by streams and torrents is enormous; and one has only to cast his eye over some lofty mountain-slope to see how deeply it is scarred and seamed and furrowed by these restless and resistless agencies. In fact, the great diversity of mountain scenery depends on this erosive power of water—all the hills and highlands depending less for their present outlines on the igneous forces by which they were upheaved, than on the meteoric and aqueous agencies to which they have been subsequently subjected.

154. Streams, like springs, subserve important purposes in the economy of nature. They constitute a great network of drainage for the land—carrying off superfluous moisture, and preventing its accumulations in bogs, swamps, and morasses. They are at once the carriers and distributors of water—dispensing in measured supplies the heavy rainfalls, melting snow and ice of the highlands, to the less rainy regions of the plains below. Geologically, they are incessant workers of change—here cutting out ravines, glens, and gorges—there filling up lakes with the eroded material; here wearing deeper channels for the further drainage of wampy lowlands, and there assisting in that universal transfer of sediments to the ocean which is destined to become the surface of future lands. Man, too, ever early locates himself on the banks, employing their perennial supplies in the wants of home, in the irrigation of his fields, or as a cheap and efficient agent in the turning of his machinery. No wonder, then, that in

times more primitive and more than our own every spring and stream had its possessing deity and seemed to be worshipped—their highest ritual marking its secondary consecration, that vivifying principle which the most enlightened intellect can trace to a higher and surer source.

RIVERS—THEIR CHARACTERISTICS.

156. As streams are formed by the union of springs and minor streams, so rivers are formed by the union of streams. In general they have their origin in some natural spring, lake, morass, or running stream, but by joining the mountains. This infant current, augmented by the accession of other springs, becomes a small stream; and this stream, by the influx of other *affluent* or *tributary* streams, very soon assumes the dimensions of a river. A river is thus said to have its *head* or *source* in some higher region: to flow along a certain *course*; to wear out for itself a *bed* or *channel*, whose margins form its *banks*; and ultimately to discharge its waters into some lake, sea, or estuary by a *mouth* or *mouths*. In other words, every river has a *rise*, *flow*, and *fall*, which form the essential features of its existence. Where the ground, in the ultimate part of a river-course, is low and level, the accumulating waters often discharge themselves by several branches, and form a *delta* (par. 88), as in the Nile, Niger, Indus, Ganges, &c.; and such deltas may be either marine, lacustrine, or fluvial, according as the rivers flow into the sea, a lake, or another larger river. Where the tides and river-currents contend, sand frequently accumulates across the entrance a spit of sand, gravel, known as a *bar*; and these bars are serious impediments to the navigation of some of the finest rivers. As all rivers flow from higher to lower levels, the terms *up* and *down* have reference to this natural condition; and as a spectator descends with the current, the *right bank* lies on his right hand, and the *left bank* on his left. When he ascends, however, this order is reversed—the right bank being then on his left hand, and the left on his right.

156. The extent of country drained by a river and its tributaries is often spoken of as the *basin* of that river (basin of the Tay, &c.); and this naturally, from the saucer-shaped aspect which such districts usually present, tends to form rivers, so several river-basins are included in the larger depression of some inland sea, as the Baltic, of the "basin of the Baltic," if

"basin of the Mediterranean," and, carrying the idea still farther, even of the "basin of the Atlantic." As the great oceans form the ultimate receptacles for all the rivers (with one or two exceptions), the river-basins that descend to any ocean constitute what is termed the *river-system* of that ocean; and thus we have the Arctic System, the Atlantic System, the Pacific System, and the System of the Indian Ocean—together with the Aralo-Caspian System, and the minor basins of Utah, the Mexican table-land, and the plateau of Bolivia, whose streams are strictly continental, and confined to these areas. The line or ridge that separates one basin or system from another basin or system is termed the *watershed* of these basins (or *watershed*, if we affect a German derivation)—all the springs and streamlets "shedding or parting off," as if from the ridge of a house, to their respective areas. Though hills and mountains generally form the boundaries between river-basins, it does not follow that watersheds should always consist of elevated ground—a few feet of fall being sufficient to determine the current in either direction. The low ridge that thus separates the streams of different basins is spoken of as a *portage* (Fr.), from the fact that goods and boats are frequently carried across from one stream to another; and thus, it may be, completing the passage by water from one side of a continent to another.

157. Such are the usual *terms* employed by geographers in treating of rivers; the *characteristics* of the rivers themselves—that is, their rise, course, length, volume, depth, velocity, capability of navigation, and the like—require more detailed consideration. As to their *rise*, it has been already stated that it generally takes place in some upland spring, lake, or morass, and not unfrequently in the melting terminus of some descending glacier. Many of these springs, especially those issuing from chasms and caverns in limestone districts, are often of considerable magnitude, being, in fact, full-flowing streams when they make their appearance at the surface. Mountain lakes, being the recipients of springs and other runnels, become in like manner copious—the streams that flow from them being already rivers in nature. The same may be said of morasses and high tracts, which, being saturated with springs and rain-charge at once regular and continuous streams. Where a lake receives a number of small feeders, it is justly as the "source" of the river to which it gives rise; but one of the feeders assumes decided importance, that feeder upon as the infant river, and must be traced to a higher or fountainhead among the mountains. Glaciers and melt-

They now are also occasional sources, and, where merely accessory, become important regulators of supply in the regions where they occur—their waters flowing freely when the summer's heat has most diminished the lowland streams.

150. Whatever their origin—and it must be confessed that the exact sources of many of our larger rivers are unexplored and undetermined—their courses are primarily directed by the general slopes of the continents. In the Old World, the great slopes being north and south, the principal rivers flow in these directions, just as in the New World their courses are easterly and westerly, in obedience to the relief of that continent. But while this is true, and necessarily so, as regards the main slopes, it should be borne in mind that there are many causes tending to modify the courses and directions of rivers. Among these, for example, may be noted the strike of the secondary hills and spurs, which are usually at right angles to the main chains; the occurrence of lines of fracture in the crust; the passage from one formation to another whose strata lie in a different direction; and the alternation of softer and harder beds—the current readily excavating its channel in the line of the former, but obstructed and turned aside in another direction by the latter. All these, and many other circumstances, concur to give streams and rivers very irregular courses, winding and bending, turning and returning, but still guided in the main by the primary slope of the region.

159. As to the *length* of their courses, that will depend primarily upon the extent of the region through which they flow—the larger area giving scope to the longest river; and, secondarily, upon the bendings and windings to which they may be subjected. The direct distance between the source and outlet of a river may not exceed two hundred miles, and yet its absolute course, through all its doublings and windings—its *development*, as it is termed—may amount to a thousand. This absolute length gives no true idea, however, of the importance of a river, either in nature or to navigation—its value mainly depending on the permanence of its volume, its depth, and velocity. The *lengths of rivers*, so often tabulated in geographical works, are, for the most part, little better than guess-work, and, even were they more accurate as to figures, they are still of little use—the real natural and economical value of a river resulting, as we have already said, from the permanence of its volume, the slowness of its current, its depth, nature of channel, accessible entrance, and influx and efflux of the tides.

160. *Volume*, size, or magnitude of a river—that is, the quantity of water which its channel contains—depends on many collated circumstances, but chiefly on the extent of country

drained by its affluents. There may occasionally be some peculiarity of basin as regards rainfall, melting of snow, and the like; but, generally speaking, the greater the area over which the tributaries ramify, the greater the quantity of water brought to the main trunk or channel. In temperate latitudes this volume is somewhat lessened in summer and increased in winter; but on the whole the supply is pretty equable and permanent. Sudden excesses, arising from heavy rainfalls, rapid melting of snow in spring, and the like, are merely temporary, producing what are termed *floods*, *freshets*, and *debacles*. In tropical countries, on the other hand, where the rains fall and the snows melt only at stated seasons, these floods assume the character of regular and *periodical inundations*. And where the rain falls in the low countries at one period, and the far-off mountain-snows melt at another, there may be two such inundations occurring with wonderful regularity both in time and amount of overflow. Again, where the sources of a river lie near the equator and its outlet in the temperate zone (as in the case of the Nile), a considerable time must elapse between the equatorial rainfall and the deltaic inundation; and the length of this lapse will depend partly on the windings of the river, and partly on the slope and freedom of the channel. In the preceding instances, whether subjected to irregular floods or periodical inundations, the river itself is always more or less *permanent*; but in some regions, as Australia and South Africa, many of their so-called rivers are merely *temporary*, being roaring impetuous torrents during the rains, and a succession of stagnant pools and dry shingly reaches during the season of drought.

161. The *velocity* of a river depends mainly on the slope or declivity down which it flows, partly on the nature of its channel, according as this may be straight or winding, deep and narrow, or wide and obstructed by rocks and shoals, and partly also on the amount or volume of its current. As all rivers descend from higher to lower regions, and many of them from very elevated sources, they may be said to have an upper, middle, and lower course—the *upper* being characterised by rapidity of stream through gorge and glen and waterfall; the *middle* by less velocity through rapids and cataracts; and the *lower* by a quiet steady flow through level and alluvial plains. Other things being equal, the deeper the river, the more rapid the current—the greater velocity being in the centre of the stream, and a little below surface, where there is least retardation from friction on the sides and bottom of the channel. “The speed, however,” it has been remarked, “does not depend entirely either upon slope or depth.”

but also upon the height of the source of the river, and the pressure of the body of water in the upper part of its course ; consequently, under the same circumstances, large rivers run faster than small, but in each individual stream the velocity is perpetually varying with the form of the banks, the winding of the course, and the changes in the width of the channel."

162. The velocity of rivers is an all-important consideration in their geographical, geological, and commercial relations. The more rapid their currents, the less the irrigating effect, and the greater the geological effect on the countries through which they flow ; and in proportion as their velocity increases, so their fitness for the purposes of navigation is diminished. Formerly a descent of more than 1 foot in 200 was considered unnavigable ; and though the power of steam has enabled man to contend with higher velocities, it is still the velocity of current more than the depth of water that renders a river unavailable as a means of internal communication. Geologically, the cutting as well as transporting power of rivers is greatly aided by the rapidity of their currents ; hence the effect of mountain torrents compared with the quiet, sluggish flow of the lowland river. It has been calculated, for example, that a velocity of 3 inches per second will tear up fine clay, that 6 inches will lift fine sand, 8 inches sand as coarse as linseed, and 12 inches fine gravel ; while it requires a velocity of 24 inches per second to roll along rounded pebbles an inch in diameter, and 36 inches per second to sweep angular stones of the size of a hen's egg. During periodical rains and land-floods the currents of rivers often greatly exceed this velocity ; hence the tearing up of old deposits of gravel, the sweeping away of bridges, and the transport of blocks many tons in weight—an operation greatly facilitated by the circumstance that stones of ordinary specific gravity (from 2.5 to 2.8) lose more than a third of their weight when immersed in water.

163. The *depth* of rivers is as various as the circumstances under which they occur, though, generally speaking, the greater the volume of water, the deeper the channel of excavation. In their upper and middle courses, the stream, being for the most part through steep rocky excavations, is of no great depth ; but in the lower and slower portion the waters accumulate and deepen as they proceed. The *outlet*, or *embouchure* (Fr.), as it is frequently termed, depends altogether upon the conformation of the country. Some rivers discharge themselves at once and by a single mouth into the ocean ; others into an estuary, and are consequently affected for a certain length by the flux and reflux of the tides ; while others, again, creep sluggishly along, branching and bifur-

eating through their swampy deltas, till they find their way into the sea by several main mouths. Seeing that the conditions of rivers are so exceedingly varied, their *facilities for navigation* will depend in each case on the nature of the outlet as accessible from sea and free from bars and banks, on depth and volume of water, and on the velocity of the current. Length of course and volume of current may be obstructed by rocks and shoals; depth and volume may be rendered unavailable by shallow bars and shifting sandbanks.

River-Systems, Oceanic and Continental.

164. It will be seen from what has been stated respecting the characteristics of rivers, that each has its own individuality, and that this individuality depends in the main on the geographical position, extent, and superficial configuration of its basin. To give an account of these basins would be to describe in detail the rivers that traverse the surface of the globe—a subject which extends beyond our limits, and belongs more especially to hydrography and general geography. All that our outline will permit is the arrangement of the basins into SYSTEMS, and a notice of some of the more remarkable rivers that belong to each system. As all the affluent streams of a river belong to one basin, so all the river-basins that descend to the same ocean-basin—whether directly, as the Niger to the Atlantic, or intermediately through some inland sea, as the Nile to the Atlantic through the Mediterranean—belong to the same river-system. In this way we have four great *oceanic river-systems*—the Arctic, Atlantic, Pacific, and Indian; and one or two minor *continental* ones, as the Aralo-Caspian, the Utah, the Mexican, and the Bolivian. To the main characteristics of these respective systems, and the leading rivers that compose them, the attention of the student is now directed.

165. The *Arctic System*, as the name implies, embraces those rivers which, obeying the northern slope of the Old and New World continents, discharge themselves into the basin of the Arctic Sea. Lying for the most part within the limit of constantly-frozen ground (See Atlas, Plate XII.), and flowing through notably level plains, there is a degree of sameness in the conditions of these waters which renders the Arctic more homogeneous in its character than any other river-system. For convenience, however, it may be divided into three sections—Asiatic, European, and American—according as the rivers belong to these respective areas.

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morasses, which render its surface still more dreary and inhospitable.

167. The European section of the Arctic river-system embraces the Petchora, which falls directly into the ocean, and the Mezen, Dwina, and Onega, which enter it indirectly through the White Sea. With the exception of the Dwina, on which Archangel is situated, and which drains an area of 106,000 square miles, none of these rivers are of much importance, being usually ice-locked from September to June, and otherwise flowing through a flat and uninviting region. This flatness, however, permits of an extended canal-system; and it is thus that the White Sea and Baltic are connected, through these northern rivers and the Volga, with the Black Sea and Caspian, just as they will shortly be by the more rapid and effective system of railway.

168. The American section comprises those streams and rivers which, obeying the northern slope of that continent, find their way through a labyrinth of lakes and swamps, and ultimately fall into the Arctic Sea. The more noticeable of these are the Great Fish, the Coppermine, the Mackenzie, and the Colville. Comparatively little is known of the sources and ramifications of these rivers, of which the Mackenzie is the largest and most important. This great river, which drains an area of 441,000 square miles, is formed by the union of several streams that rise in the eastern slopes of the Rocky Mountains. The most important of these are the Athabasca and Peace rivers, which, after passing through Lake Athabasca, unite to form the Slave River; and this, after entering the Slave Lake, reissues as the Mackenzie. Like the rivers of Siberia, those of Arctic North America flow through low, frozen, and inhospitable swamps, and enter the sea by wide mouths; but, unlike those of Siberia, they are connected with a labyrinth of lakes, a feature peculiarly characteristic of the northern section of the American continent.

169. The *Atlantic System*, as the name implies, embraces all those rivers that find their way directly or intermediately into the great basin of the Atlantic from the slopes of the adjacent continents. It necessarily arranges itself into four sections—the European, African, North American, and South American—according as the rivers descend from either of these continents. In the European section we have certain rivers that flow in Atlantic directly, and others that enter it indirectly through the Baltic and Mediterranean. The chief of those flowing directly are the Elbe, Weser, and Rhine from the western slopes of the Germanic plain; the Seine, Loire, and Garonne from the

France; and the Danube, Tagus, Guadiana, and the Spanish peninsula. The Rhine—the basis of the German—springs from Alpine sources at a high level, descends rapidly to Lake Constance (2250 feet), the Falls of Laufen to Basel (800 feet), and thence, a course, to the North Sea, which it enters by the English delta. The Rhine has thus a well-marked course, a development of 300 miles, and a drainage square miles; the Loire an absolute course of 102 drainage of 23,000 square miles; while the Tagus (importance) has a length of 300 miles, and a drainage square miles. The principal streams that flow through the intermediate basin of the Baltic are the Vistula, and Oder—all more or less obeying a northward flow, their coasts, levelled for a considerable time. Of these the Vistula (whose windings nearly equal its nine-tenths of its direct course) finally has the greatest development and drainage being 595 miles, and its basin 58,000 square miles.

170. The waters that fall from the European basin of the Mediterranean are—the Ebro and Ródano; the Po into the Gulf of Venice; and the Rhodanus, Danube, and Don into the Euxine Sea. Among the Alps at an elevation of 3500 feet, and, its course of only 300 miles, is necessarily one of the main rivers of Europe. It has a drainage of 23,000 square miles, and, when in high flood, its fresh waters can be seen several miles out at sea. The waters of the Rhodanus branch of the Mediterranean basin (southern and south-eastern slope of the European basin) the Don, Danube, and Dniester have comparatively small courses, and all in their lower courses flow through plains, which, during a large portion of the year, are covered with snow and morasses. The Danube, the longest river in the Black Forest at an elevation of 1400 feet, has a course of 1496 miles, and an area of drainage of 1,100,000 square miles. It is formed by the confluence of several mountain streams, and, as the Donau or Danube in the Danube basin, it runs through an Alpine country to Ulm, where it traverses the plain of Bavaria. From Ulm it flows generally through a flat country, except at the "Iron Gate," till its embou-

able tributaries—the Theiss, Drave, and Save—form important hannels of internal communication for eastern Europe—an importance that has been greatly enhanced by the adoption of samers fitted to the peculiarities of their currents.

171. Such are the principal rivers of Europe that fall directly indirectly into the basin of the Atlantic. Lying in the temperate zone, and having their sources at no great distance from the an, their volumes are wonderfully regular and persistent, being ely liable to occasional floodings from excess of rainfall, or from len meltings of the snow in early spring. The extent and igation of the continent prevent the formation of large and rivers; but as the rapids and waterfalls are confined to their r stages, the lower portions of their courses are in most ines easy of access and more or less navigable. Whether d as channels of drainage and irrigation, or as means of al communication, these rivers constitute an essential fea-n the physical geography of Europe. Flowing from the l region in every direction, they equalise the water-supply than in any other continent, confer greater beauty and y on its surface, and afford at once a perennial supply available mode of intercommunication to its busy popu-

The African section of the Atlantic system embraces all vers which flow from the western and northern slopes of tinent—the former discharging themselves directly into , the latter indirectly through the basin of the Mediter- Of those entering directly into the Atlantic, the Senegal, Niger, Congo, Coanza, and Orange are the more import-gh still but very partially known in their middle and rses. The Senegal and Gambia, which rise in the Kong , and have courses from 600 to 850 miles in length, form it basins of Senegambia, and are navigable to some ex-Niger, the noblest of these western rivers, is supposed sources in the northern slopes of the Kong Mountains, t circuitous course of more than 1500 miles, during eives the Chadda and other large tributaries, enters be- yable mouths the Gulf of Guinea. The Niger (Jo trains an immense but unknown extent of tr a navigable middle course of many hundred t one to six miles in width, and running at the r t miles an hour; and possesses a low, pestile- 0 square miles, alternately choked with the rail and overspread by inundation, which attains

The following information was obtained from the records of the [redacted] Department of the Interior, Bureau of Land Management, regarding the [redacted] National Monument, located in the State of [redacted].

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[illegible]

miles a-minute, the current flows gently through the plains of Egypt, till its final discharge into the Mediterranean by the two main mouths which form its delta. This delta commences 90 miles from the sea, and has a coast-line of 187 miles between its main mouths, the Rosetta and Damietta. In the plain of Egypt, which is from 2 to 18 miles in width, the current of the Nile, when not in flood, is about $2\frac{1}{2}$ miles an hour, but in its delta branches the flow is almost imperceptible. The most remarkable feature in the Nile is the regularity of its annual inundation, which arises, in all likelihood, from rainfalls dependent on the south-east trade-winds of the Indian Ocean, and on the melting of snows among the equatorial ranges near its sources. In its upper branches the river begins to rise in April, but at Cairo the flood is not perceptible till towards the summer solstice. It then continues to rise for nearly a hundred days, and remains at its greatest height till the middle of October, when it begins to subside, and reaches its lowest point in April and May. So far as we have evidence, this inundation has remained unchanged for the last 4000 years. Its height in Upper Egypt is from 30 to 35 feet, at Cairo from 20 to 24, and in the northern part of the delta, where it spreads out over a wider area, it seldom exceeds 4 or 5 feet. The fine black slime or mud deposited by this inundation has been the unfailing source of wealth and fertility to Egypt, and from its accumulation, in like manner, has arisen the formation and increase of the delta.

[Speaking of the source of the Nile, Captain Speke in his 'Journal' affirms that "the most remote waters, or top head of the Nile, is the southern end of the Lake N'yanza, situated close on the third degree of south latitude, which gives to the Nile the surprising length, in direct measurement, rolling over thirty-four degrees of latitude, of above 2300 miles, or more than one-eleventh of the circumference of the globe. Now, from this southern point, round by the west, to where the great Nile stream issues, there is only one feeder of any importance; for the travelled Arabs one and all aver, that from the west of the snow-clad Kilimandjaro to the first degree of south latitude there are salt lakes and salt plains, and the country is hilly, not unlike Unyamuézi; but they said there were no great rivers, and the country was so scantily watered, having only occasional runnels and rivulets, that they always had to make long marches in order to find water when they went on their trading journeys; and further, those Arabs who crossed the strait when they reached Usoga, as mentioned before, crossed no river either. There remains to be disposed of the 'salt lake,' which I believe is not a salt, but a fresh-water lake; and my reason, as before stated, that the natives call all lakes salt, if they find beds or salt islands in such places. Dr Krapf, when he obtained a son of the Kenia mountain, heard from the natives there that there was a lake to its northward; and he also heard that a river ran from Kenia towards the Nile. If his information was true on this latter point, then, without doubt, there must exist some connection between his river and the salt lake I have heard of, and this in all probability would also establish a connection between my salt lake and his salt lake, which he heard was called

Baringo. In no view that can be taken of it, however, does this unsettled matter touch the established fact that the head of the Nile is in 3° south latitude, where, in the year 1858, I discovered the head of the Victoria N'yanza to be." Again, referring to the river as it issues from the lake by the "Ripon Falls," he says—"Though beautiful, the scene was not exactly what I expected; for the broad surface of the lake was shut out from view by a spur of hill; and the falls, about 12 feet deep and 400 to 500 feet broad, were broken by rocks. Still it was a sight that attracted one to it for hours,—the roar of the waters, the thousands of passenger-fish, leaping at the falls with all their might; the Wasoga and Waganda fishermen coming out in boats, and taking post on all the rocks with rod and hook; hippopotami and crocodiles lying sleepily on the water; the ferry at work above the falls, and cattle driven down to drink at the margin of the lake, made in all, with the pretty nature of the country—small hills, grassy-topped, with trees in the fields, and gardens on the lower slopes—as interesting a picture as one could wish to see." And as the young river held on its downward course, the country and scenery were most beautiful. "It was the very perfection of the kind aimed at in a highly-kept park; with a magnificent stream from 600 to 700 yards wide, dotted with islets and rocks, the former occupied with fishermen's huts, the latter by sterna and crocodiles basking in the sun,—flowing between fine high grassy banks, with rich trees and plantations in the background, where herds of the nsunnu and hartebeest could be seen grazing; while the hippopotami were snorting in the water, and florikan and guinea-fowl rising at our feet."]

174. The rivers of South America constitute by far the most unique and gigantic section of the Atlantic system. Indeed, all the rivers of that continent obey its great eastern slope towards the Atlantic—the streams that flow down the abrupt and rainless counterslope towards the Pacific being mere runnels fed by the melting snows of the Andes. In this case we have at once area for development, supply from heavy rainfalls engendered by the moisture-laden winds of the Atlantic, as well as from melting snows and perennial springs, and breadth of volume arising from the flatness of the surface over which these rivers flow. Beginning at the south, the rivers of Patagonia are of little importance, being described as "of small magnitude, with few or no affluents, and making straight across the dry shingly terraces of that sterile region." North of this the great river-system commences, embracing the basins of the Plata, the San Francisco, the Paranahybe, the Tocantins, the Amazon, Orinocco, and Magdalena.

175. The Rio de la Plata, whose drainage is estimated at 886,000 square miles, receives its affluents from very distant and different regions—the Salado, Vermejo, and Pilcomayo from the deserts and salinas of the Lower Andes—the Paraguay and Parana, two noble rivers, from the wooded slopes and verdant plains of the central regions—and the Uruguay from the low sierras and valleys of southern Brazil. Some of these affluents, like the Paraguay and Parana, are navigable for hundreds of miles inland, and, on the whole, have deep and accessible channels, but are subject to

of the Plata—a fresh-water sea, 180 miles long, and its entrance ; but shallow and loaded with mud, its salination is perceptible far out the Atlantic. The San Pablo, having a length of 1400 miles, and an estimated drainage of 1,000,000 square miles ; the Paranahyba, having a drainage of 1,000,000 square miles ; and the Tocantins, or Para, of 284,000 square miles—are strictly Brazilian rivers, rising among, and flowing through, the sierras of that country. Little is known of their sources, but they descend with considerable currents till they reach the lowlands that fringe the Atlantic, from which they are carried to long distances inland.

The Amazon, by far the largest river in the world—having a length of 3500 miles from its remotest feeder (the Apurimac) in Peru to its union with the ocean, and an estimated drainage of 4,000,000 square miles—is that which gives life and character to the lowlands of tropical America. Entering the ocean by an outlet 100 miles long and 130 broad, its freshening influence is carried 1000 miles out at sea ; while, on the other hand, its rise is perceptible at the distance of 576 miles from the mouth. The main stream, though much impeded by mud-bars and islands, is navigable for 2000 miles inland, and will, by one or other, become the highway of commerce and civilisation through the fertile and exuberant region through which it flows. Its principal affluents on the right are the Xingu, Tapajós, Marañón, Purus, and Ucayali, which flow from the sierras of Brazil into the central region ; and on the left the Rio Negro, the Japura, the Putumayo, which descend from the mountains of Parí and the northern Andes. Many of these tributaries are largely navigable, and, though treated as mere feeders of the Amazon, would be esteemed important rivers in the geography of other countries. The head-waters of the Amazon drain the entire circle of the Andes, almost connecting its stream by a low portage with the Rio Paraguay on the south, and actually uniting it by the Casiquiare with the channel of the Orinoco on the north. Like other tropical rivers, the Amazon is subject to periodical inundation—its waters beginning to rise in December, being at their greatest height in March, and lowest in July and August. When in flood its waters overspread an immense extent of country, which becomes alternately a fresh-water sea, and *selvas* teeming with the rankest tropical vegetation.

177. The Orinoco—the last of South American rivers to which our space will permit us to advert—has a basin of nearly 300,000 square miles, and a navigable course at all seasons of more than 1000 miles.

1000 miles. Rising in the mountains of Parimé, it takes a circuitous course northwards and then eastwards, receiving on the one hand several important tributaries from the Andes, and on the other a number of smaller streams from the ranges of the Parimé. Increased by these affluents—the Guaviare, Meta, and Atures on the left, and the Paraqua and Caroni on the right—it ultimately finds its way by a perfect labyrinth of mouths into the basin of the Atlantic, whose tides flow upwards into its main channel for more than 250 miles. Its annual floods take place with great regularity—commencing about the end of March, and decreasing by the end of August. During high flood, thousands of square miles of the low flat basin are inundated to a depth of 30 feet—these flats, alternately flooded and covered with long rank grass, constituting the celebrated *llanos* of the Orinoco.

178. The river-systems of North America are governed by the disposition of the Rocky Mountains much in the same way as those of South America are governed by the Andes. The counterslope of the Rocky Mountains, being less abrupt than that of the Andes, gives development to two or three streams of some importance on the Pacific side, but in the main the great river-basins are directed towards the Atlantic. The central plain that stretches from the Gulf of Mexico to the Arctic Sea being divided by a low watershed of 1300 or 1500 feet, a few rivers, as the Mackenzie and Coppermine, trend northward to the Arctic basin, but all the larger and more important lie south of this watershed, and belong to the Atlantic system. Of these the Rio del Norte and the Mississippi fall into the Gulf of Mexico; the St Lawrence directly into the Atlantic; and the Saskatchewan and Churchill into Hudson Bay. The Rio del Norte, which rises among the sierras of New Mexico, has its upper course through a desert region, in which it receives few affluents; but as it descends into the lower grounds it gains considerable accessions, and becomes a natural boundary between the United States and New Mexico. Its drainage area is estimated at 180,000 square miles.

179. The Mississippi ("father of waters") is by far the largest of North American rivers. Rising in the small lake of Itasca, on the verge of the middle table-land, at an elevation of 1500 or 1600 feet, it runs southward through the great central plain, receiving numerous accessions from either side, and, after a winding course of 3160 miles, falls through a swampy delta into the Gulf of Mexico. Its main tributaries on the right or Rocky Mountain side, in which they take their rise, are the Missouri—a river even longer, larger, and having more affluents, than the Mississippi itself—the Arkansas, having also many affluents, and the Red

river; while on the left its chief tributary is the Ohio, with its numerous feeders from the western slopes of the Alleghanias. Between the Rocky Mountains on the west, and the Appalachians on the east, lies, therefore, the great conjoint basin of the Missouri, Mississippi, and Ohio, having an area of more than a million square miles; containing every description of soil and scenery—prairie, barren, and woodland; watered by innumerable streams and several navigable rivers; and possessing every variety of climate, from the coldly-temperate highlands of Nebraska to the sub-tropical warmth of the Gulf of Mexico. The Mississippi, we have said, has a winding course of 3160 miles, but if the Missouri be taken as the main stream, its length is 4260 miles; while that of the Arkansas is 2000, and the Ohio more than 1000 miles. The breadth of the Missouri and Mississippi at their confluence is about half a mile, and the main stream downwards is very little more. Though gentle, the current is by no means sluggish; and thus, during floods, from the melting of the snow in the higher latitudes, the rivers sweep downwards immense quantities of mud, driftwood, and other debris. The Missouri is said to be navigable “from the Great Falls in the Rocky Mountains to the sea, a distance of 4000 miles; the Mississippi, from those of St Anthony, 2240; while the Ohio, being connected by a system of canals with Lake Erie, and thence to Lake Ontario, carries out a water-communication between the Gulfs of Mexico and St Lawrence.” The delta of the Mississippi, which projects itself forward into the Gulf of Mexico, is a low and unhealthy region, nearly 14,000 square miles in area, and full of lagoons, creeks, and pestilential marshes.

180. The St Lawrence, which forms the great water highway to Canada, takes its rise, under the name of the St Louis, far west in the central lake-region of North America. After uniting the Lakes Superior, Huron, Erie, and Ontario, it issues from the last by the name of the Iroquois, and, alternately contracting and expanding into lake-like reaches, it is known as the St Lawrence at Montreal, from whence it flows to Quebec, and thence by its long estuary into the Atlantic. Its drainage basin is estimated at 297,000 square miles, of which 94,000 or more is covered by fresh-water lakes. Its estuary is 350 miles long, and 80 broad as its mouth, but, from its northward trend, is frozen and ice-locked during the winter. The Saskatchewan and Churchill take their rise, in like manner, among the labyrinth of lakes that characterises the extreme northern plain of America, and, after flowing from lake to lake with irregular and tortuous courses, find their way to the North Atlantic through Hudson Bay. The basin

ling and Pe-ling, wind with slow and steady flow through the plain of China into the Yellow Sea. The course of the Hoang-Ho, or Yellow River (so called from the colour of its waters), is estimated at 2300 linear, and its basin at 537,000 square miles; while the course of the Yang-tse-Kiang is 2900 linear, and its drainage area not less than 548,000 square miles. Though their main mouths are wide apart, yet they may be said to fall into the same delta—their broad navigable streams being united throughout their lower courses by innumerable canals and natural channels. Indeed the whole country, from the southernmost branch of the Yang-tse, north to the Pei-ho, or White River, which enters the Pe-che-le Gulf, is one alluvial flat, intersected by channels, canals, and embankments, and liable to be flooded and broken in upon by shiftings of the river-courses, and other similar changes. The burden of sediment which these rivers carry down to the shallow basin of the Yellow Sea is immense; and though frequently shifting their channels, and encumbered by sandbanks, they are navigable by vessels of considerable burden for 600 or 800 miles, and by smaller craft to perhaps double that extent. The Mekong is a large but little-known river, rising in the mountains of Eastern Assam, flowing with a long course between the mountain-ranges of Cochin-China, draining, along with the Menam, an estimated area of 216,000 square miles, and falling into the Gulf of Siam or Cambodia by a many-mouthed delta.

183. *The river-system of the Indian Ocean* has three separate and independent sections—the Asiatic, the Australasian, and the African, according as the rivers flow from either of these regions. The Asiatic embraces the Martaban and Irawady in Burmah; the Brahmapootra, Ganges, and Indus in India; and the Tigris and Euphrates in Persia and Asia Minor. The Martaban, Irawady, and other rivers of Further India, occupying the narrow valleys which lie between the parallel hill-ranges of that region, flow southward in long and comparatively straight courses. Very little is known of their sources or affluents; but the Irawady, which enters the Gulf of Martaban by a many-branching delta, is navigable for 400 or 500 miles, and though encumbered in lower course by mud-banks and islands, is a channel of vast importance to the Burmese empire. During the season of in-tion it spreads to a breadth of 3 or 4 miles, runs at the rate of 4 or 5 miles an hour, and is heavily laden with sedimentary matter. There is, indeed, a great similarity among all the rivers of the Indo-Chinese peninsula, whether flowing like the Menam and

Mekong into the Pacific, or like the Martaban and Irawady into the Indian Ocean: they have long straight courses, flow with considerable current through a country rich in tropical vegetation, and enter the sea by several mouths through low and gradually-increasing deltas.

184. The Ganges, which rises at an elevation of 13,000 or 14,000 feet among the glaciers of the Himalaya, descends rapidly to the plain of India, and there flowing with gentle current it receives numerous affluents from the southern slopes of its parent mountains on the one hand, and from the northern slopes of the Vindhya high grounds on the other, till it ultimately falls through a many-branching delta into the Bay of Bengal. The Brahmapootra ("offspring of Brahma") is formed by the union of two main streams, the Dzangho-chur, which has its origin in the northern slopes of the Himalayas, and flows eastward till its union with the Brahmapootra proper, which, descending from the distant recesses of the Tibetan mountains, runs southward towards Assam. After their junction the united waters, under the name of the Brahmapootra, cut transversely the eastern Himalayas, and then, flowing south and westward with a volume considerably exceeding that of the Ganges, enter the delta of that river about 40 miles above the sea, but still maintain the individuality of their own channel. The conjoint area drained by these rivers and their affluents (several of which are larger than the Rhine) is estimated at 432,000 square miles, and their respective lengths at 1680 miles. Like other tropical rivers, the Ganges and Brahmapootra are subject to annual inundations—the floods commencing in April, attaining their maximum about the middle of August, and continuing till October. They begin first to swell from the melting of the snows among the mountains, but before influence has reached the low grounds these are widely under from the periodical rainfalls. The quantity of water from these two causes and brought down by the Ganges and Brahmapootra is enormous, overspreading the plains for hundreds of square miles, and freshening more or less the whole area of the Bay of Bengal. The amount of sediment brought down by these rivers when in flood is also immense; and the whole delta, 100 miles in length and 180 broad at its base, (including its creeks, lagoons, and mud-islands (Sunderland), is covered by this debris. Though liable to frequent inundations, several of the branches of the main stream are navigable at all seasons for vessels of large tonnage. The main stream can be ascended by smaller boats, and the whole of the Himalayas. Though possessing a large

volume, the Brahmapootra, from the rapidity of its current and the obstacles in its channel, is of less importance as a means of internal communication.

185. The Indus, the third great river of India, takes its rise in the highlands of Thibet, and after a precipitous course through the western Himalayas, descends into the plains, where it is augmented by the streams of the well-known Punjab, or Five Rivers. These affluents, like the main stream, are the offspring of the Himalayas, and drain a large expanse of upland as well as fertile lowland. After their union near the southern extremity of the Suleiman hills, the Indus receives no more tributaries of any note, but flows with gentle current through a somewhat arid country for nearly 300 miles, and then forks into a delta 80 miles long by more than 100 broad at its base, discharging itself by many mouths, only three or four of which are navigable. The annual floods commence with the melting of the Himalayan snows in April, attain their greatest height in July, and terminate in September. The winding course of the river is nearly 2000 miles, and its estimated drainage 312,000 square miles; but owing to the shallow and shifting nature of its mouths it is navigable only by vessels of comparatively small burden. Lying open to the great tidal wave of the Indian Ocean, it has, like the Ganges, a rapid and dangerous *bore*, which ascends the main channels to a distance of 60 or 70 miles.

186. The only rivers of importance that enter the Indian Ocean from western Asia are the Euphrates and Tigris—celebrated in ancient history, and still flowing through a fine but neglected country. Their conjoint drainage-basin is roughly estimated at 200,000 square miles, and both have well-marked upper, middle, and lower courses. The Euphrates and its affluents rise in the table-land of Armenia, and after a long and tortuous course the main river descends in rapids through the Taurus chain into the plain of Mesopotamia. The Tigris and its tributaries rise in a similar manner to the east, in the highlands of Kurdistan, pierces also in its middle course the Taurus chain, and thence descends by a slow and winding channel through the Mesopotamian plain. Both rivers flow parallel for a long distance through this beautiful lowland, and ultimately join at Korna, a distance of 150 miles

head of the Persian Gulf, which receives their united development of the Euphrates, the greater river, is estimated at 100 or 1800 miles, fully one-third of which flows through. Naturally one of the most fertile and exuberant. "The Tigris and Euphrates, once the seat of an extensive and of art, civilisation, and industry (Babylon, Nineveh,

&c.), are now, however, nearly deserted, covered with brushwood and grass, dependent on the rivers alone for that luxuriant vegetation which, under an admirable system of irrigation, formerly covered them." The floods of the rivers are said to be very regular in their rise and fall—beginning in March, and attaining their greatest height in June.

187. Australia, owing to its geological conformation, is singularly destitute of rivers—those descending the eastern counterslope of its hills into the Pacific being mere streams, while those flowing from their western slopes seem to lose themselves in the great central and yet unexplored plain. The Murray, with its tributaries the Darling, Lachlan, and Murrumbidgee, are the only known rivers of note, and these, though roaring torrents during the rains, are often reduced to a mere chain of ponds and creeks in the dry season. Of the African rivers that enter the Indian Ocean, geography knows too little as yet to offer anything like reliable description. So far as known, the Zambesi, now under exploration by Dr Livingstone, is the largest and most important, apparently draining an immense extent of inland country, which spreads out in plain-like expanses, reticulated by lakes and streams that flow during the periodical rains, but are desiccated and partially obliterated during the season of drought. On the whole, recent investigation seems to point to the interior of Central Africa as a plateau-shaped plain, deriving its main water-supply from rains, which form, for the most part, only temporary streams and lakes—the surplus being carried off by evaporation rather than by a regular system of stream and river drainage.

188. Such is a brief outline of the chief river-systems of the world—the Arctic, Atlantic, Pacific, and Indian. Though the basins of which they are composed have their own individual characteristics, there is still a great similarity, and necessarily so, among the various members of a system. Thus the rivers of the Arctic system run more or less meridionally, flow from *warmer to colder* latitudes, and all their embouchures are for a large portion of the year ice-locked and impervious to navigation. By the melting of the snows in their upper courses they are flooded before the thaw has reached their lower waters, and thus the plains through which they pass are largely occupied by lakes and morasses. The rivers that descend the southern slopes of Asia, Europe, and North America, flow also in meridional courses, but pass, on the contrary, from *colder to warmer* latitudes, and consequently their embouchures are open at all seasons. Those of them that belong to the Atlantic system derive their floods chiefly from the melting of

the snows along their upper courses; while the inundations of those belonging to the Indian system depend partly on the melting of the snows and partly on the periodical rainfalls in their lower courses. With the exception of the Rio del Norte and the Mississippi on the one hand, and the rivers that enter the Mediterranean on the other, all the basins of the Atlantic system, whether from the American, European, or African continents, run in latitudinal courses; and thus, from their sources to their embouchures, each passes along the same climatological zone. These and other great conditions must at once present themselves to the mind of the inquiring student, and produce the conviction that the idea of *river-systems* has something more to recommend it than the mere convenience of artificial arrangement.

189. Besides the oceanic systems there are what have been termed *Continental Systems*—a few inland basins cut off from all connection with the ocean, and having the equilibrium of their waters maintained by evaporation and absorption. The chief of these, as already mentioned, are the Aralo-Caspian basin in Asia; the Utah and Mexican in North America; the basin of the Andes plateau in South America; and in all likelihood, when better known, some similar depressions in Australia and Central Africa. On referring to the map it will be seen that a number of the streams of Central Asia—the Asiatic plateaux—run inland to lakes or lose themselves in the sand and shingle of the desert. This is the “Basin of Continental Streams” in Asia, and includes the Lob, Balkash, Helmund, and other lake-hollows, with their tributary streams; the Aral, with its main feeders the Syr and Amoo; and the Caspian, with its rivers the Oural and Volga. Of these the most important is the Volga, which rises on the Valdai slopes at an elevation of 550 feet, and, after a long and winding course of 2400 miles, during which it receives many important tributaries (the Kama, Viatka, &c.), falls by two main mouths into the Caspian Sea, which is 82 feet below the level of the Euxine. The Volga is the largest river in Europe, has a fall of only 633 feet during a course of 2400 miles, drains an estimated area of 397,640 square miles, and constitutes the great internal water-way of Russia. The seas and lakes of this basin, as indeed of all other continental basins, having no escape for their waters save by evaporation, must necessarily be more or less salt; and hence the saline peculiarities of the Caspian, Aral, Balkash, Dead Sea, Lake of Utah, and others occurring in these so-called “basins of continental streams.” Basins of this kind necessarily occur in rainless flats and plateaux; for were the amount of rainfall exceeding the

evaporation, the sheets of water would accumulate till they overflowed their margins, and found an outlet, like other lakes, towards the nearest oceanic area.

ABSTRACT OF RIVER-SYSTEMS.

ARCTIC.

	<i>Drainage Basin.</i>	<i>Length.</i>	<i>Development.</i>
	Sq. m.	Geog. m.	Geog. m.
Obi,	924,800	1276	2320
Yenesei,	784,530	1228	2300
Lena,	594,400	1230	2400
Kolyma,	107,200	440	800
Indigirka,	86,400	500	910
Olenek,	76,800	600	1000
Anadir,	63,400	...	...
Dwina,	106,400	380	864
Petchora,	43,800	360	600
Mesen,	30,580	...	...
Saskatchewan,	360,000	924	1664
Mackenzie,	441,600	964	1154
Churchill,	73,600	668	850
Albany,	52,800	380	560

ATLANTIC.

Neva,	67,200	315	440
Rhine,	65,230	360	800
Vistula,	56,640	280	520
Elbe,	41,860	344	684
Oder,	39,000	280	480
Loire,	34,000	320	520
Duna,	33,440	280	560
Niemen,	32,180	240	400
Duero,	29,250	260	440
Garonne,	24,450	200	320
Seine,	22,620	220	340
Tagus,	21,960	360	480
Guadiana,	19,360	240	420
Guadalquivir,	15,000	180	260
Weser,	13,100	200	280
Minho,	11,840	198	192
Nile,	520,200	1320	2300
Rhone,	29,950	232	352
Po,	28,180	248	560
Ebro,	25,100	268	420
Danube,	234,080	880	1496
Dnieper,	169,680	548	1080
Don,	163,420	408	960
Dniester,	23,050	360	440

	Drainage Basin.	Length.	Development.
	Sq. m.	Geog. m.	Geog. m.
Great Lakes and St Lawrence, .	297,600	860	1800
Connecticut,	8000	231	270
Delaware,	8700	180	265
Orinocco,	252,000	370	1350
Essequibo,	61,650	350	420
Amazon,	1,512,000	1548	3080
Tocantins,	234,430	990	1120
Paranahyba,	115,200	560	744
S. Francisco,	187,200	870	1400
La Plata,	886,400	1028	1920
Mississippi-Missouri,	982,400	1412	3560
Rio del Norte,	180,000	1220	1840
Magdalena,	72,000	560	830

PACIFIC.

Amoor,	582,880	1200	2380
Yang-tse-Kiang,	547,800	1550	2880
Hoang-Ho,	537,400	1150	2280
Tche-Kiang,	99,200	480	960
Columbia,	194,400	576	1360
Colorado,	169,000	512	800

INDIAN OCEAN.

Ganges and Brahmapootra,	432,480	821	1680
Indus,	312,000	900	1900
Menam,	216,000	600	1480
Euphrates,	195,680	600	1500
Godavery,	92,800	540	750
Kistua,	81,000	440	690
Irawady,	331,000	1100	2200

CONTINENTAL SYSTEMS.

Volga,	397,400	900	2400
Oural,	53,200	550	...
Kour,	64,600	300	640
Sir,	237,000	600	1200
Amoo,	193,000	800	1400
Lob Lake,	177,000	620	1000

Lakes and Lacustrine Areas.

190. *Lake* is the general term for any considerable body of standing water surrounded by land, and not directly connected with the sea or any of its branches. Lakes are thus strictly terrestrial expanses, and belong to the land as much as the streams and rivers that channel its surface. Wherever there is a depression of that surface beneath the surrounding country or the bed of the nearest river, there water will accumulate (unless carried off by evaporation) till it rises above the lowest part of the enclosing

margin and flows off by some river-channel. In this way we may have sheets of all sizes, from the merest pools to lakes occupying many thousands of square miles. Lakes generally consist of *fresh water*; but some, like the Caspian and Aral, having no river of discharge, are *salt*, while others, having only partial outlets, are *brackish*. They occur in all regions, but most abundantly on mountain table-lands and plateaux, and on the lower reaches of great plains. Wherever there is a want of declivity, or any obstruction to the natural flow of the surface-waters, there lakes will accumulate, and this in proportion to the extent of country, the magnitude of the obstruction, and the amount of rain and snow-fall. In consequence of less evaporation, they occur also more abundantly in low than in high latitudes; and hence their frequency and magnitude in the northern regions of America, Europe, and Asia, as compared with other areas.

191. It is usual to arrange lakes into *four* kinds :—1. Those that have neither outlet nor inlet—subterranean springs and rain supplying the water, and evaporation carrying off the excess. These are generally of small dimensions—lowland pools, mountain tarns, and not unfrequently the craters of extinct volcanoes. 2. Those which have an outlet, but receive no running water, being fed by springs rising from their bottoms and rocky margins. Lakes of this class are also small, and for the most part situated in upland districts. 3. Those which, like the Caspian and Aral, receive streams of running water, but have no visible outlet—the balance of level being maintained by evaporation. Such lakes are more or less impregnated with saline matter; and this saltiness must be still on the increase. 4. Those that both receive and discharge streams of running water, and which form alike the most numerous and most extensive in both hemispheres.

192. To whatever class they belong, lakes form essential elements of diversity in the landscape, and perform important functions in the economy of nature. Exposing considerable surfaces to evaporation, they serve to temper the aridity of their respective districts, at the same time that they act as so many reservoirs, in which the superabundant supplies of winter are stored up for the increased requirements of summer. In many instances they act as checks to the too rapid discharge of rivers—retaining for perennial supply what would otherwise be run off in a few days, and restraining, moreover, the destructive flood which is brought to rest in their placid areas. Occurring so frequently in the course of rivers, they act, as settling pools for the debris and sediment of their streams they discharge being pure and pellucid, while the water they receive may be turbid and laden with impurities.

ties. In this way they get gradually silted up, and form rich alluvial tracts, the while that their outlet-currents are deepening their channels and forming the means of a more efficient drainage. In this way lakes become important agents in the surface-modification of the land; and one has only to cast his eye over the fertile dales and vales of long-established regions to perceive how much of these areas was at one time a mere succession of lakes and morasses. Biologically, too, these fresh-water sheets become the habitats of a peculiar flora and fauna—thus extending the range of Life, and affording conditions of existence that no other habitat could supply.

193. In Europe there are two main lake regions—a highland and a lowland; the former embracing the picturesque lakes of Britain, Switzerland, and Italy; the latter the numerous sheets that stud the Baltic provinces of Russia, Prussia, and Sweden. The highland lakes generally occupy the deep narrow troughs of mountain-glens, and from their situation and adjuncts are celebrated for their scenery; the lowland, on the other hand, spread over areas little depressed beneath the surrounding country, and are for the most part tame and unattractive. The waters of Highland or Alpine lakes are usually retained by rocky barriers, through which the outflowing stream is gradually deepening its channel, and thus their dimensions become less and less as the drainage outlet becomes deeper. On the contrary, the drainage of lowland sheets is often slow and sluggish; hence a large portion of their areas is little else than morass, which the accumulation of aquatic vegetation and sedimentary matter is year after year converting into alluvial land.

194. With two or three exceptions (*Platten See*, *Nieusidler See*, &c.), the European lakes, strictly so called, consist of fresh water; they have all, or nearly all, streams of ingress and egress; vary in size from a few hundred square yards to several thousand square miles; rise slightly with the rains of winter and fall with the droughts of summer. The more notable of those in the northern lowland region are *Lakes Ladoga* 6330 square miles, *Onega* 3280, *Saima* 2000, *Peipus* 1250, and *Enara* 1200 square miles, in Russia; and *Lakes Wener* 2130, *Wetter* 840, and *Maala* 760 square miles, in Sweden—the latter being only three or four feet above the level of the Baltic. The larger Alpine lakes are on the Swiss side; *Geneva* or *Leman*, 240 square miles, at elevation of 1230 feet; *Constance*, or the *Boden See*, 228 square miles, at an altitude of 1250 feet; *Neufchatel*, 114 square miles, and 1440 feet high; *Lucerne*, 98 square miles, and 1430 feet high, and *Zurich*, 74 square miles, at an elevation of 1330 feet: while

on the Italian side there are Garda 182, Maggiore 150, and Como 66 square miles, at elevations respectively of 320, 680, and 685 feet. In the British Isles, Loughs Neagh, Corrib, Erne, and Loch Lomond, respectively 150, 63, 56, and 45 square miles in area, and 48, 31, 130, and 22 feet in elevation, are the largest, though others of smaller dimensions are better known for their picturesque scenery and associations.

195. In Asia, the lakes occupy three main and distinctive regions—the mountains and plateaux of the central highlands, the alluvial lowlands of China and Siberia, and the depressed areas of the Aralo-Caspian and Dead Sea. Unlike those of Europe, many of the Asiatic lakes are salt or brackish, and this peculiarity belongs more especially to those having no river of outlet. Respecting these salt or brackish sheets, accounts differ considerably as to the amount of saline matter held in solution in their waters—a difference that may arise either from taking the specimens at different places, at different seasons, or from errors in analyses. Whatever the source of error, there can be no doubt that where new saline supplies are continually carried in by rivers and springs, and none carried off by running water, the percentage must be gradually on the increase. Of the *saline* lakes the more important and better known are the Caspian (slightly fresher than the ocean), 82 feet beneath the level of the Black Sea, having an area of 130,000 square miles and an extreme depth of 960 feet; the Aral, 36 feet above sea-level, and having an area of 26,000 square miles; Balkash or Tengiz, having an area of 7000 square miles; Urumiah (25 per cent of salts), 1800; Van, 1600; Zurrarah, 1600; Tongri-nor, 1800; Koko-nor, 1500; Lob, 1300; and the Dead Sea, 360 square miles, with a depression of not less than 1312 feet beneath the level of the Mediterranean, and containing from 25 to 26 per cent of saline ingredients. Of the *fresh-water* sheets the largest is Baikal (the “Holy Sea” of the Russians) in Siberian Tartary, with an area of 14,800 square miles, and at an altitude of 1535 feet; and Tong-Ting, Poo-Yang, and Tai-Hou in China, having respectively areas of 2000, 800, and 700 square miles, and all valuable aids to the internal communication, commerce, and agriculture of that peculiar country. Besides these may also be noted Zai-zan in Mongolia, 1000 square miles; Booka-nor in Tibet, 1000; Erivan in Armenia, 500; and Tiberias in Syria, 76 square miles, at a depression of 328 feet beneath the Mediterranean.

196. In Africa there are several lakes less or more known to geographers; but while the internal configuration of that continent remains undetermined, it is impossible to arrange them into

anything like systems or areas. Between the Atlas range and the Sahara, and fed by streams from the former, there exists a series of minor lakes, of which the largest (Loudeah, &c.) lies in Tunis; in the hilly region of Nigritia the existence of sheets of considerable magnitude (Tchad, Dobbie, Fittie, &c.) has been so far determined; in the equatorial region, Victoria N'yanza, Baringo, and other reservoirs of the Nile; and in the southern table-land, several shallow and apparently fluctuating sheets (Ngami, Nyanja, Taganyika, &c.) have been partially explored. Among the longer known lakes may be mentioned Dembea or Tzana in Abyssinia, at an elevation of 6270 feet, and embracing an area of 1400 square miles; the deltaic areas of Menzaleh and Mareotis in Egypt; and the salt-water lake of Assal in Abyssinia, extending to 30 square miles, and lying in a depression 570 feet beneath the level of the Red Sea. With regard to Australia, we know that certain areas covered with water during the rains are but marshes or mud-pools during the season of drought, and that, along many portions of the sandy coasts, there exist saline and brackish lagoons; but we are yet too slenderly acquainted with the interior to speak with certainty as to the existence of *lakes*, in the true sense of the term, either fresh-water or saline.

197. In South America there are comparatively few lakes, and these, for reference sake, may be arranged into three distinctive regions—namely, the mountain-glens and depressions of the higher Andes; the low plains that border the eastern flanks of the Andes; and the still lower river-plains that trend toward the Atlantic. Of the Andian lakes the most remarkable is Titicaca, situated at an elevation of 12,847 feet, embracing an area of 3800 square miles, and stamping peculiar features on the scenery, life, and civilisation of the surrounding district. It is fed by several streams from the Andes, but discharges itself by a single outlet, the Desaguadero, which after a short course disappears, partly by evaporation and partly by absorption into the sandy and arid soil through which it flows. Of the lakes that skirt the Andes on the east, many of them are of temporary nature, being extensive sheets during the rains, but mere marshes and salt pools (*salinas*) during the period of drought. In the lower plains of the Plata, Amazon, and Orinocco there exist many creeks, lagoons, and stagnant areas that appear in the dry season as lakes, and during the rains as one vast area of inundation.

198. In North America the lakes may be said to affect only two main districts—a highland and a lowland; the former the troughs and depressions of the Rocky Mountains from Panama on the south to Columbia on the north, and the latter the north-

the rocky crust reappear at the surface as *springs*, which, according to their situation, may be superficial or deep-seated; according to their supply, temporary, intermittent, or perennial; according to their temperature, cold or thermal; and according to the rocky material through which they pass, either pure or mineral—that is, impregnated less or more with saline, calcareous, siliceous, chalybeate, and other mineral and metallic substances. By their union, springs and surface rivulets form *streams*, and these streams occurring most abundantly in hilly regions unite, one with another, as they descend to the plains, and there ultimately form *rivers*, whose continually augmented volumes constitute one of the most important features in the hydrography of the globe.

The highest or farthest-off spring to which we can trace a river constitutes its *source* or *rise*; and from this source, through all its windings till it finally falls into the sea by one or by many mouths, lies its *course*. It is usual to divide river-courses into upper, middle, and lower stages—the upper being characterised by ravines and waterfalls, the middle by rapids and cataracts, and the lower by a broad gentle current which often finds its way into the ocean by several branches through a low-lying and marshy delta. The track worn or hollowed out by running water constitutes its *channel*, and the land that forms the margins of this channel is known as its *banks*—that on the right hand as we descend the current being termed the right bank, the left hand the left. The streams that enter any river or main current from either side form its *affluents* or *tributaries*, and the entire expanse of country drained by a river and its tributaries is said to be the *basin* of that river. An ideal line, connecting the ultimate sources of all the tributaries of a river, forms the *watershed* of its basin; and generally speaking, the ridge from which the streams of a country flow in opposite directions is the watershed of that region. As all the streams of a river-basin fall to the lower level of that basin, so several river-basins may descend to the still broader basin of some sea or ocean, and all such basins discharging themselves into the same sea constitute a *river-system*.

The river-systems are necessarily coincident with the great oceans into which they flow; and thus we have the Arctic, the Atlantic, Pacific, and Indian systems, together with a few inland systems whose streams flow towards certain depressed areas together cut off from connection with the ocean. These are the Aralo-Caspian basin, the Utah, the Mexican, the Bolivian, whose waters flow inwards to certain lakes, and are thence carried off by evaporation. Where the slopes of a country are pre-uniform, the surface waters are at once carried off by streams al-

XI.

THE ATMOSPHERE—CLIMATOLOGY.

Nature and Constitution of the Atmosphere.

199. HAVING, in the preceding chapters, directed attention to the leading features of the Land and Water—the mountains, table-lands, and plains of the one, and the seas, lakes, and rivers of the other—we now proceed to consider the main relations of the Atmosphere or aerial envelope (Gr. *atmos*, vapour, and *sphaira*, a sphere) by which the whole is surrounded. What is the nature and composition of this envelope, what its capacity for heat and moisture, what are the motions to which, as an elastic fluid, it is subjected, and generally, what are its conditions as the great medium of climate (heat, cold, winds, rains, &c.) on which the Life of the globe is so intimately dependent? This varied subject of climatology belongs more especially to the science of Meteorology; but as an integral portion of the globe, and bearing on everything—organic and inorganic—that presents itself at the surface, the atmosphere and its principal phenomena become important themes to the student of Physical Geography.

200. As already stated in paragraph 19, the atmosphere surrounding the globe, and partaking in all its motions of revolution and rotation, is an aëriform fluid consisting of nitrogen and oxygen gases—79 parts of the former to 21 of the latter by volume, together with a small and variable percentage (.05 to .10) of carbonic acid gas and other impurities. These gases are merely in a state of admixture or diffusion, as is also the invisible vapour which is ever present in the atmosphere. This species is alike indispensable to vegetable and animal life, and plants breathe, if we may so speak, the carbonic acid is exhaled by the former, it is absorbed by the latter, which in turn exhale oxygen elements of the animal kingdom. By this means the

and lighter volumes will ascend, and the colder and denser rush in from all sides to supply the vacancy. In this way currents or *winds* are originated in the atmosphere, and on these currents depend in a great measure the essentials of climatic diversity. As a property of the gaseous or aëriform nature of the atmosphere, the vapour or minute watery vesicles, generated from the earth's waters by the heat of the sun, ascend and are diffused through its mass in an invisible state. This humidity of the atmosphere also decreases with the height, and this in so rapid a ratio that at the altitude of 5 or 6 miles it is all but inappreciable. These vapours, invisible at first, become visible on being condensed by colder currents; hence arise fogs, mists, rains, snows, and other kindred phenomena. The effective portion of the atmosphere, so far as its heat and moisture are concerned, lies, therefore, within a few thousand feet of the earth's surface, all above the limit of 5 or 6 miles being inoperative or nearly so in the production and regulation of climate. As the atmosphere is the medium through which the sun's heat is conveyed to and disseminated over the earth, so also it is the medium of his light-giving rays. Heat and light are alike indispensable to plants and animals, and, from the peculiar constitution of the atmosphere, as regards its varying density, moisture, &c., both are reflected and diffused so as to become most available to vegetable and animal life.

[With regard to the *functions of the atmosphere*, the following beautiful passages from the pen of our early friend and fellow-worker—the late Dr George Buist—will be appreciated by the student whose mind is duly alive to the chain of harmonies that links together the remotest members of our cosmo-system:—“We have already said that the atmosphere forms a spherical shell, surrounding the earth to a thickness which is unknown to us, by reason of its growing tenuity, as it is released from the pressure of its own superincumbent mass. Its upper surface cannot be nearer to us than fifty, and can scarcely be more remote than five hundred miles. It surrounds us on all sides, yet we see it not; it presses on us with a load of fifteen pounds on every square inch of surface of our bodies, or from seventy to one hundred tons on us in all, yet we do not so much as feel its weight. Softer than the finest down, more impalpable than the finest gossamer, it leaves the cobweb undisturbed, and scarcely stirs the lightest flower that feeds on the dew it supplies: yet it bears the fleets of nations on wings around the world, and crushes the most refractory substances by its weight. When in motion, its force is sufficient to level the earth the most stately forests and stable buildings, to raise the w of the ocean into ridges like mountains, and dash the strongest ships pieces like toys. It warms and cools by turns the earth and the creatures that inhabit it. It draws up vapours from the sea and lays them dissolved in itself or suspended in cisterns of clouds; throws them down again, as rain or dew, when they are required; bends the rays of the sun from their path to give us the aurora or morning and twilight of evening; it disperses and refracts their var tints to beautify the approach and the retreat of the orb of day. But

dependent on the heat of the sun—the amount conveyed from within (paragraph 18) or radiated from the moon and other external sources being by far too feeble to have any perceptible influence. As is well known, the solar rays exercise the greatest effect within the tropics, where they fall vertically or nearly so on the earth's surface, and that this effect gradually declines as we proceed through the temperate zones towards either pole. In other words, the higher the angle at which the sun's rays strike the earth the greater their heating power, and the lower the angle the less the amount of heat imparted. We feel the truth of this every summer-day, when the sun is high a-head during the scorching noontide, and when his beams fall at a lower angle during the cooler afternoon. At whatever inclination they fall, there is always, as before explained, a certain amount of heat lost or extinguished in passing through the atmosphere; and this amount for nearly vertical incidence within the tropics has been estimated at one-third; for inclinations of less than 25 degrees at fully one-half; while at inclinations of 5 degrees scarcely one-twentieth of the solar heat is supposed to reach the surface. In this way $23^{\circ} 44' 40''$ on either side of the equator forms a belt within which the solar heat received is equal to what is received by all the rest of the world; hence the student will perceive the applicability of the terms "torrid," "temperate," and "frigid" zones. Keeping out of view all minor modifications produced by the peculiar disposition of sea and land, as well as by the sun's alternate passage to the northern and southern hemisphere along the course of the ecliptic, it may be received as the first great axiom, that the superficial temperature of the globe is highest under the vertical incidence of the sun's rays near the equator; and that it gradually becomes lower and lower as we proceed towards either pole, and this in proportion to the obliquity at which the heat-giving rays fall upon the surface.

205. The heat that falls on the land being partly absorbed and partly radiated into the atmosphere, the lower aerial strata, or those nearest the influence of this radiation, will be warmer than those at higher elevations. The rate at which this diminution takes place depends, as has been shown by Mr Glaisher's balloon ascents in 1863, on many correlative circumstances—dry moisture, currents, &c.; but as an approximative rule, the crease may be reckoned as equal to 1° of Fahr. for every 350 feet of ascent. In this way the lower plains of a region be teeming with vegetation while the higher mountains are covered in perpetual snow. We have thus two great causes affecting the superficial temperature of the globe—distance from

above the level of the sea; so that at any point the same whether we travel towards the summit of a lofty mountain. In both we will meet with a constant increasing temperature, in both we will meet with a similar limit in animal and vegetable life, and in both we will encounter such a limit of perpetual ice and snow. In the case of elevation this limit is known as the *snow-line*, at which the air in summer attains the temperature of freezing water and is then slightly modified by surrounding circumstances, it varies continually with the latitude—ascending from 2000 feet within the polar circle to 15,000 or 16,000 feet in the vicinity of the equator. In the case of horizontal extension, the *line of constant temperature* differs in either hemisphere—that in the northern is that of latitudes assuming an irregular course, in the southern of the unequal distribution of sea and land, and that of the southern being less determinable in consequence of the greater expanse of Atlantic Ocean.

One of the principal subjects of research in the balloon experiments of 1863 was the determination of the law of decrease of temperature with increase of elevation. It is a subject to which very great interest is attached, and to the determination of which a great deal of labour and research has been devoted, resulting in the adoption of the theory of a uniform rate of decrease of 1° of Fahr. for every increase of 300 feet. The results from my several ascents were that, when the sky was clear, a decline of 1° took place within 100 feet of the earth, while at the height of 8,000 feet a space of fully 1000 feet had to be passed for a change of 1° of temperature; and that between these limits a gradually increasing space was required for a change of temperature to the same amount, finally indicating that the theory of a decline of 1° of temperature for every 300 feet of elevation must be abandoned. The previous eight balloon ascents were made in the months of July, August, and September. It became of the highest importance to have similar experiments in the other months of the year; and the British Association, at its meeting in Cambridge, voted £500 for further experiments to be begun in the spring, and some of these, if possible, during the prevalence of the east wind. The first of these ascents took place in March 1863 from the grounds of the Crystal Palace. The balloon left the earth at 4h. 16m. p.m., the temperature of the air being 50° . At 4h. 25m. we were 10 miles high, with a temperature of $33\frac{1}{2}^{\circ}$; the second mile was reached at 4h. 25m., with a temperature of 26° ; the third mile at 4h. 44m., when the temperature was 14° ; and at $3\frac{1}{2}$ miles high the temperature was 8° . A current of air was met with, and the temperature rose to 12° at 5m.; at 5h. 2m. we passed out of this current, and when $4\frac{1}{2}$ miles the temperature was just zero of Fahrenheit's scale. In descending the temperature increased to 11° at about three miles high, at 5h. 38m.; a cold current was met with, and it decreased to 7° . We soon passed through it, and the temperature increased to $18\frac{1}{2}^{\circ}$ at two miles high to the ground, which was reached at 6h. 30m. The air was very dry at heights exceeding four miles the temperature was 40° .]

of variation in atmospheric temperature is

the unequal reception and radiation of the sun's heat by the respective surfaces of land and water. The heat falling on the land is partly absorbed and conducted downwards into the soil, and partly radiated into the atmosphere. The amount absorbed will differ according to the colour, slope, and character of the land (dry, firm, and dark-coloured soils being most favourable for absorption); and according also as it is naked or shut out from the sun's rays by a covering of vegetation. The amount radiated differs with almost every passing condition of the atmosphere—radiation going rapidly forward under a still, clear sky, while a cloudy atmosphere, or even a passing mist, serves to retard it. The greater quantity of heat absorbed by day is given off by night; and the amount accumulated during summer is returned to the atmosphere during winter. The depth thus affected by summer's heat or winter's cold will differ according to latitude, soil, and situation,—the soil in Siberia, for example, being never thawed beyond the depth of a few feet, while under the equator the sun's influence has been known to extend to the limit of 90; but, on the whole, it may be safely asserted that beyond 60 or 80 feet the temperature of the earth's crust is little or at all affected by external influences. Indeed, for all practical purposes the superficial temperature of the land, as affecting climate, may be regarded as confined to a very few feet beneath the surface—the slow conducting power of the soil and capillary attraction of moisture from below combining to limit its downward tendency.

207. On the other hand, the heat that falls on the water is much more readily absorbed, but more slowly radiated, so that, being diffused by waves and currents, it penetrates to a considerable depth, and accumulates within the mass of the ocean. The heat that falls on any zone of the land is absorbed and radiated wholly within that zone; whereas that falling on any zone of the ocean is diffused and interchanged between every other zone. As the ocean radiates its heat more slowly than the land, and exposes more than thrice the surface to the sun's rays, it becomes, as it were, a great storehouse of heat for the exigencies of the land. It is for this reason that islands and seaboard possess a milder and more equable climate than the interior of continents—being warmer during winter and cooler during summer. The British Islands, with their comparatively cool summers and mild winters, are said to possess an *insular climate*; while the interior of France, with its excessively hot summers and cold winters, on the contrary, to possess a *continental climate*. In the interior, unaffected, of course, by winter, the interior is always much warmer than the sea-coasts and

adjacent islands. It is also for this reason that the northern and southern hemispheres, having unequal distributions of sea and land, are differently affected in their zones of climate—the greater extent of land in the northern imparting to it, as it were, a continental climate; while the greater expanse of ocean in the southern confers on its similar latitudes more of an insular climate. It is, further, to this unequal reception of heat by land and water that we owe the phenomena of sea and land breezes. During day the atmosphere immediately above the land is more rapidly heated by radiation than that above the ocean, hence the cooler sea-breeze sets in towards the land to restore the balance; while during the absence of the sun the more rapidly cooled land-atmosphere sets out as a land-breeze towards the more slowly cooling surface of the ocean. In fine, it is mainly owing to the unequal distribution of sea and land, and to the different modes in which the two elements are affected by the sun's heat, that we owe the great essentials of climatic diversity—the air and ocean-currents, the vapours and rains, of one region, varying from the winds, currents, and moisture of another.

208. Whatever the temperature of the air, it is incessantly receiving *moisture* from the surface of the land and water. This vapour arises and is diffused through its mass in an invisible form, and becomes visible only when condensed into mists, fogs, rains, and snows. It arises alike from land and water, but most copiously and persistently, of course, from the surface of the water. The superficial moisture of the land, unless where clothed with vegetation, is rapidly converted into vapour; but the supply from this source is irregular and limited compared with that derived from the water. Surface for surface, salt water is less vaporisable than fresh; hence a slight check to evaporation from the vast and extended surface of the ocean. It arises from rivers, lakes, and seas in every latitude, but most abundantly, of course, within the tropics, where the sun's heat is the greatest. So great is the evaporation within that zone, that it has been estimated as annually sufficient to reduce the surface of the sea to a depth of 8 or 10 feet—a waste, of course, that is incessantly counterbalanced by influx from other latitudes. The warmer the air the greater its capacity for moisture; and this capacity for holding moisture in suspension increases up to the point of saturation, when any reduction in temperature produces condensation, and rain ensues. In case of other meteorological phenomena, the circle of their production and retention of atmosphere is extremely complicated: but in general terms

it may be stated that heat is the grand promoter of evaporation ; that a gentle current of air, by removing the pressure of the vapour as it is formed, is more favourable than a stagnant atmosphere ; and that it is retarded by moist and cloudy conditions of the air, even though the sensation of heat be considerable. As previously mentioned, the humidity of the atmosphere is confined chiefly to its lower strata ; and so rapidly does the quantity diminish as we ascend, that at the height of five or six miles it becomes all but inappreciable. The quantity of moisture evaporated from the surface of the globe may differ from day to day, and from year to year ; but on the whole, and for any given number of years, it is returned again in the state of dew, rain, hail, or snow. Understanding the general conditions of the atmosphere as regards its heat and moisture, we may now proceed to its special effects in the production of winds, rains, and other kindred phenomena.

Winds—Constant, Periodical, and Variable.

210. As already explained, any current of the atmosphere produced by inequality of temperature or density is termed a *wind*—the denser and colder air rushing in to supply the place of the lighter and warmer. In other words, *wind is air in motion* ; and the most frequent cause of such motion is disparity of temperature between adjacent districts. As inequality of temperature is ever arising alike from general and from local causes, the occurrence of winds is incessant and universal, either along the earth's surface, or in the higher strata of the atmosphere. While the colder current is flowing *below* from the colder to the warmer region, a warm current is floating *above* from the warmer to the colder. As the homogeneity of the ocean is maintained by its currents, so the equilibrium and uniformity of the atmosphere is preserved by its winds. These winds, having different times, directions, and characters, are necessarily arranged into different classes, and distinguished by various designations.

211. As regards times, those blowing constantly in one direction between, and within a few degrees beyond, the tropics (Trades), are spoken of as *permanent winds* ; those blowing certain periods (the Monsoons, &c.), as *periodical* ; and those obeying no fixed period, as *variable*. As concerns direction, they are distinguished by the points of the compass, as North, South, East, West, South-west, South-south-west, &c., according to the quarter from which they blow. And as regards inherent or c.

matic character, they are cold or hot, dry or moist, gentle or boisterous, healthful or unhealthful, according to locality and other accompanying conditions. One of the most obvious characteristics of winds is their velocity, which may vary from a few miles to upwards of a hundred miles an hour; and between these extreme rates we have every variety, from the gentlest zephyr to the most violent hurricane. According to meteorological authorities, a velocity of 7 miles per hour is regarded as a gentle air; of 14, as a light breeze; of 21, a good sailing breeze; of 41, a gale; of 61, a great storm; of 82, a tempest; and of 92, a hurricane, producing universal devastation—tearing up trees and sweeping away buildings. Or more minutely, according to their *velocity* and *force*, they have been arranged as follows:—

Velocity in Miles per Hour.	Force in lb. Avolrd. per Square Foot.	Common Appellation.
1	.005	Breath of air.
4	.079	Gentle air.
5	.123	Light wind.
10	.492	Brisk wind.
15	1.107	Light breeze.
20	1.968	Brisk breeze.
25	3.075	Stiff breeze.
30	4.429	High wind.
35	6.027	Gale.
40	7.873	Strong gale.
50	12.300	Storm.
60	17.715	Great storm.
80	31.490	Hurricane or tempest.
100	49.200	Violent hurricane.

212. In whatever character they occur, winds are important agents in the production and modification of climate. By their agency the moist and heated atmosphere of one region is transferred to another; and on their agency also depend, in a great measure, those currents of the ocean which are ever producing interchanges between the colder and warmer surface-waters of different latitudes. Besides these great climatological functions, they are intimately concerned in the production of rains and other aqueous phenomena; while their incessant commotions tend to preserve the atmosphere in ever-healthful equilibrium. They are the great bond, as has been well observed, between the land and water surfaces—transferring the moisture of the one to the thirsty uplands of the other, and the dry cold air of the former to disperse and rarefy the humid and depressing atmosphere of the latter. Geologically, winds have considerable effect in removing, piling

up, and re-assorting all loose superficial matters, as the sand-dunes of the sea-shore and the sand-drift of the desert; while through the agency of the ocean-waves, which are created by their power, important changes are produced along every shore of the world. In their gentler manifestations they assist in the fertilisation of plants and in the dispersion of their seeds; while in their fiercer demonstrations their track is marked by ruin and devastation. By their impulse the commerce of distant nations is wafted from shore to shore; and fickle and fitful as they may appear, man not unfrequently avails himself of their power to turn the wheels and shafts of his machinery.

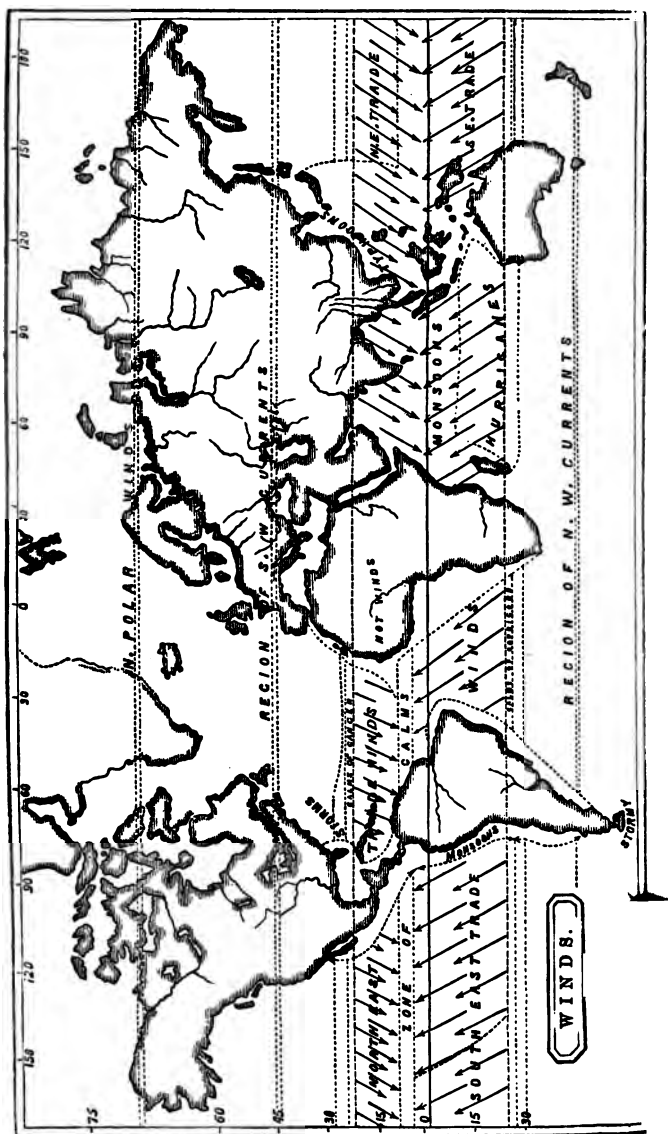
213. The most remarkable of the *permanent, constant, or perennial* air-currents are the TRADE WINDS (so called from their influence on the trade or commerce of the world), which, within the torrid zone and a few degrees beyond it on either side, are ever sweeping round the globe in a westerly direction. This is occasioned by the fact that the region near the equator is most intensely heated—the other zones becoming colder and colder towards either pole. Under these circumstances, the air of the torrid zone becomes rarefied and ascends, while the colder and denser air sets in from either side to supply the deficiency. There are thus generated two great sets of currents—colder under-currents setting in towards the equator respectively from the north and south, and warm upper-currents flowing off from the equator towards either pole. If, then, the atmosphere were subject to no other influence than temperature, a *north wind* would always prevail along the earth's surface in the *northern hemisphere*, and a *south wind* in the *southern hemisphere*. But as the polar currents proceed towards the equator, they gradually come into zones having a greater velocity of rotation, and thus they are deflected in a westerly direction (as exhibited in the accompanying Sketch-Map), so as to become a *north-east* wind in the northern hemisphere, and a *south-east* wind in the southern.

214. In the Pacific, the north-east trade-wind may be said to prevail between the 25th and 2d degree of N. latitude; while the south-east trade ranges more widely between the 10th and 21st of S. latitude. In the Atlantic, on the other hand, the former is comprised between the 30th and 8th degree of N. latitude and the latter, within the 3d of N. and the 28th of S. latitude. These limits, however, are not altogether stationary, but depend on the seasons—advancing towards the north during the summer of the northern hemisphere, and receding to the south as the winter withdraws to the southern tropic. Within these somewhat fluctuating zones, the trade-winds are steady and perennial, travelling

at the rate of from ten to twenty miles an hour, and wafting on-wards in safety the merchandise of the globe. As they approach the continents, their courses become interrupted in consequence of the unequal heating of the land and water surfaces; hence within these coast-areas they assume the character of periodical, rather than of constant currents, being deflected at certain seasons from their normal directions.

215. As the north-east and south-east trades approach the equator of temperature, their currents begin to fail, and this effect, augmented by the upward tendency of the highly heated air of that region, produces a zone or belt of calms, which fluctuates a few degrees north and south, according to the seasons. If the approaching trades be equally reduced in any locality, a dead calm will be the result; but as this is seldom the case, the zone is also characterised by short gusty winds, which vary in force and direction according as either main current prevails. This *zone of calms and variables*, as it is termed, is further characterised by the frequency and intensity of its thunder-storms—the crossing and collision of currents of unequal densities being favourable to the manifestation of electrical phenomena. In the Atlantic, the region of calms (see Sketch-Map) ranges in August between 3° and 12° N. lat.; but in February it extends from 1° 15' to 6° N. lat. A portion of this zone near the Cape Verde Isles is known to sailors as the “rainy sea;” and is described as “a region doomed to continual calms, broken up only by terrific storms of thunder and lightning, accompanied by torrents of rain. A suffocating heat prevails, and the torpid atmosphere is disturbed at intervals by short and sudden gusts, of little extent and power, which blow from every quarter of the heavens in the space of an hour—each dying away ere it is succeeded by another. In these latitudes vessels are sometimes detained for weeks.” In the Pacific, the region of calms is comprised within the 2d degree of north and south latitude, near Cape Francis and the Galapagos Islands—a narrow belt separating the two trades, and characterised by the same phenomena as the calm zone of the Atlantic.

216. Besides the trade-winds, which are the most persistent of all aerial currents, there are certain winds in the higher latitudes that also blow with considerable continuity. The heated air which ascends from the tropics, and flows off towards either pole, gradually descends as it proceeds; but as it passes from latitudes having a high to others having a less rotatory velocity, it is deflected from its original course, and assumes a south-easterly direction in the northern hemisphere, and a north-easterly in the southern. In this way the prevailing winds in the higher latitudes



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aphical peculiarities of the regions in which they occur. April to October, the *south-west* monsoon prevails north of the equator, and the *south-east* in the southern hemisphere; but from October to April the *north-west* monsoon blows south of the equator, and the *north-east* in the northern hemisphere. Of course, farther from the equator, the later in the season will the south-east and north-west monsoons occur; and thus it happens that in India, at Anjengo, on the Malabar coast, $8^{\circ} 30'$ N. lat., the south-west monsoon commences as early as the 8th of April; at Bombay, 19° N. lat., about the 15th of May; in Arabia it commences a month earlier than on the coast of Africa; and in the northern part of Ceylon, fifteen or twenty days earlier than on the coast of the Indian mandel.

19. The cause of the monsoons is to be sought in the effect produced by the sun during his apparent annual progress from the tropic to the other, and has been thus explained:—"In the Indian Ocean, for example, as the sun advances towards the north, the zone of greatest rarefaction recedes from the equator, and the north-east monsoon (which is nothing more than the trade-wind) then subsides, and is succeeded by calms and variable winds; but when the summer approaches, and the sun arrives at the northern tropic, the southern portions of the Asiatic continent become hotter than the ocean, and the humid air from the equatorial seas flows northward to the land; south-west winds will therefore arise, which prevail from the peninsula of India to the Arabian Gulf, until the time of the autumnal equinox. During the same period the south-east monsoon, in the southern hemisphere, tempers the heat of Lower Guinea, and brings rain to the shores of Brazil. The motions of the atmosphere, however, are *reversed* as the sun crosses the equator and approaches the southern tropic. Pouring his fervid rays upon Southern Africa, the vast tract of New Holland, and the splendid clime of Brazil, the air flows in from the north and north-west towards these highly heated regions, and winds from these quarters prevail for several months—the monsoon extending along the coast of Brazil from Cape St Augustine to the Isle of St Catherine. But now the influence of the sun is partially withdrawn from Southern Asia; it glows no longer beneath its vertical rays, and over the cooled earth the north monsoon resumes its wonted course."

20. Equally remarkable for their persistency, though local in their areas and limited in their times, are the *land and sea breezes*, which occur on almost every seaboard, but most notably, of course, within the tropics. As formerly explained, these breezes arise from the unequal heating of the land and water surfaces, and

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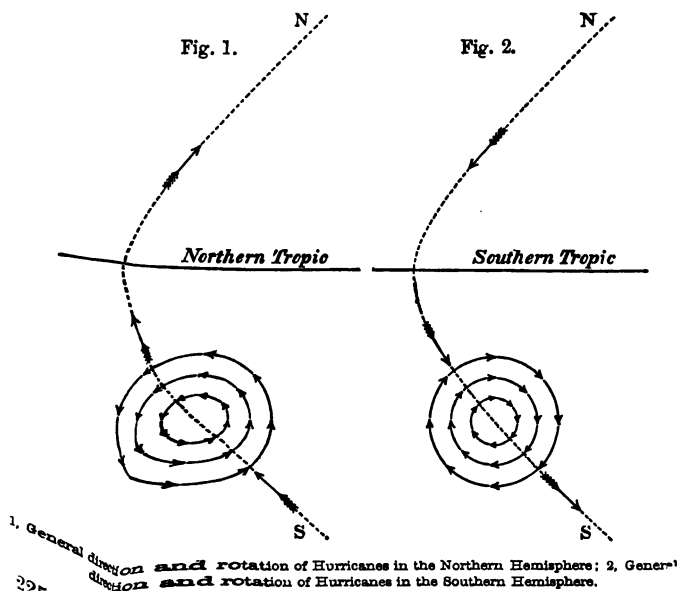
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stood if we remember that in advancing along their course the south-west tends always to become more west, and the north-east more and more east; we shall see that the result of this disposition ought to be, whenever they meet and change places, a rotation from west by north to east, and from east by south to west. In the place of the conflict of the two currents, the wind will then blow successively from three different regions, and in this order, until it is established in the direction of that one of the currents which has overpowered the other. But no one of these transition winds blows for any great length of time. In the southern hemisphere the order of succession is the reverse."

[Referring to the winds of the northern hemisphere, the eloquent author of 'Earth and Man' has the following suggestive remarks:—"This conflict of polar and equatorial winds, opposite in character and direction, gives to our climate one of its most characteristic features, that changeableness, that extreme variety of temperature, of dryness, and of moisture, of fair weather and of foul, that uncertainty of the seasons, which always keep the merchant and the farmer in anxious suspense, between the hope of a good harvest and the fear of a dearth. Not only are the variations in the same year considerable, but they are still more so from one year to another. The system of these currents oscillates from east to west, and changes place. The polar winds will prevail in a country, and will endanger the crops by the prolonged dryness of their atmosphere; while further east or west the trade-wind will spread fertility by its beneficent rains. Or the opposite: the south winds acquire such a preponderance, that the harvests perish by the moisture; while, at a somewhat greater distance, on the limit of the same wind, Nature lavishes all her treasures upon the labourer. It has been remarked that a mild winter in Europe corresponds frequently to a severe winter in America and Asia; while the mildness of the winter in America affords a presumption of a colder winter on the other side of the Atlantic. The years 1816 and 1817 were marked, as is known, in the history of Europe, by a general famine and distress. The wet was such that the harvests failed entirely. But the south-west wind, which blew without cessation over the western part of the continent, and which drenched it in its vapours, did not extend beyond Poland; and it was the south of Russia whose corn supported famished Europe for many long months. Then was revealed the commercial importance of those countries, hitherto unknown, and constantly increasing since. Who does not still remember the immense impulse given to the commerce between Europe and America by the drought of 1848, which damaged the corn-crop in Europe while America had an abundant harvest? These examples alone tell us the important part played in the life of nations by those variations of the atmospheric currents belonging to our temperate countries."]

222. Generally speaking, in the higher latitudes of the northern hemisphere, a south wind is warm and moist, because it comes from warmer regions, and passes over a greater extent of ocean; while, on the contrary, and for opposite reasons, a north wind is cold and dry. It is for this reason that the westerly and so westerly winds of Europe are humid and genial, and the north and north-easterly hard and ungenial. These major currents are of course much modified in their passage over certain localities, and

icanes that visit (generally from June to November) the seas of Southern China, and the adjacent archipelago of the Philippine and Molucca islands. *Cyclone* (Gr. *kuklos*, a circle or whirl), on the other hand, is now the technical term applied by navigators to those rotatory hurricanes which occur most frequently between the equator and the tropics, and near the equatorial limit of the trade-winds. They sweep round and round with a progressive motion, their course describing a curve, and their violence being greater the nearer the limit of their whirl. In both hemispheres the rotation of a cyclone is *contrary* to that of the sun—those in the northern hemisphere moving counter, so to speak, to the motion of a watch-hand; those in the southern following that motion, as indicated in the following diagrams:—



225. The following succinct statement of the characteristics of cyclones may be found useful by way of recapitulation. It has been fully ascertained that in both hemispheres the cyclone rotates in a direction *contrary* to that of the sun. Thus in the northern hemisphere, the course of the sun being from east to south, west, and north, the course of the hurricane is

from north by west, south, and east ; and in the southern hemisphere, the sun's course being east by north, west, and south, the hurricane runs from north by east, south, and west. 2d. They rotate in the space between the equator and the tropics, near the equatorial limit of the trade-winds. 3d. There is no instance on record of a hurricane having been encountered on the equator, nor of any one having crossed the line, though two have been known to be raging at the same time in the same meridian, but on opposite sides of the equator, and only 10° or 12° apart. 4th. Their movement, which is always oblique, from the equator to the poles, is usually from east to west at first, and towards the end west to east, which is but a development of the gyratory motion that forms their most essential characteristic. 5th. The motion of translation varies from so low as 9 miles an hour to 43 miles an hour. There is no precise estimate of the velocity of the gyratory motion. 6th. They are liable to dilate and contract in area, the contraction always implying a great accession of violence.

XII.

THE ATMOSPHERE—CLIMATOLOGY.

Dew, Rain, Hail, Snow, &c.

226. CLOSELY connected with the winds, and greatly influenced in their character by them, are the dews, rains, snows, and other aqueous phenomena which enter so largely into the determination of climate. The consideration of these subjects belongs especially to the province of Meteorology, but as much may be here recapitulated as will enable the student to trace their connection with the subject of Physical Geography. As already stated, insensible vapour to a greater or less amount is always present in the atmosphere as one of its accidental ingredients. The warmer the air the greater its capacity for this moisture; hence the greater amount taken up during the heat of the day. After sunset the earth and air lose their heat by radiation into space, but the former parts with it more rapidly; hence on its cooled surface the moisture in the air is condensed as *dew*—just as the outside of a cold-water bottle is bedimmed or *bedewed* with moisture on being brought into the warmer air of a sitting-room. Dew is, therefore, the moisture insensibly deposited from the atmosphere on the surface of the earth; and what is termed the *dew-point* is that temperature of the atmosphere at which it begins to be precipitated. The quantity of dew deposited during any night may be ascertained by a *drosometer* (Gr., dew-measurer); and perhaps the most simple process is to expose to the open air bodies like locks of wool, whose exact weight is known, and then to weigh them afresh after they are covered with dew.

227. Dew never begins to be deposited upon the surface of any body until it is colder than the contiguous atmosphere; and the quantity deposited depends chiefly upon the humidity, serenity and tranquillity of the atmosphere, as well as on the constitution, surface, and locality of the bodies receiving the moisture. Still clear nights are, therefore, more favourable for the deposition of

dew than windy and cloudy ones; and all substances like glass, silk, wool, grass, &c., which rapidly lose their own heat and slowly acquire that of others (that is, good radiators but bad conductors), are susceptible of being copiously bedewed; while substances like rocks and metals, which possess opposite qualities, contract but little dew. Bodies freely exposed to the atmosphere are more rapidly bedewed than those in any way screened or sheltered: and those near the soil more copiously wetted than such as are placed only a few inches higher. It is thus that the grassy turf is often pearly with dew while the taller herbage is comparatively dry; and the open country refreshed when the fall within towns is imperceptible. In temperate zones, where the frequent interchange of sun and shower preserves the earth from the extremes of heat and moisture, very little dew is deposited; but in tropical regions, where the day-heat is excessive, and no rain falls for months, the dews are most abundant and refreshing. But for this beneficent arrangement many intertropical countries would be altogether sterile and barren of vegetation. It must be remembered, however, that over arid deserts, where the air is excessively dry, there will be little or no dewfall, no matter what the intensity of nocturnal radiation. And in contrast to this it may be noticed that (all other things being equal) the most abundant dews occur in the neighbourhood of coasts, lakes, and rivers, where the atmosphere is in general more highly charged with moisture.

228. When the temperature of the air is reduced below that of the invisible vapour it contains, the moisture becomes visible, and appears as *fogs*, *mists*, and other kindred phenomena. These fogs occur most abundantly along the courses of rivers, on mountain-sides, over shoals and banks at sea, and generally along the sea-boards of continents and islands; and this obviously in consequence of the unequal temperature of the contiguous lands and waters. "In countries," says Kaemtz, "where the soil is moist and hot, and the air moist and cold, thick and frequent fogs may be expected. This is the case in England, the coasts of which are washed by a sea at an elevated temperature. The same is the case with the polar seas of Newfoundland, where the Gulf Stream, which comes from the south, has a higher temperature than that of the air." Like dews and rains, fogs exercise a refreshing influence on vegetation; and in some countries, like Peru, their occurrence is periodical and regular. *Clouds* have been defined as "masses of visible aqueous vapour which float in the sky, or drift through it with the wind, assuming every variety of colour and form." As clouds, they exercise but an indirect effect on terrestrial climate; and it is only when they break, by further condensation, into rain,

snow, and hail, that they come directly within the province of the geographer.

["Meteorologists distinguish, according to form, and consequently physical characters, three *primary* sorts of clouds—the cirrus, cumulus, and stratus; and four *secondary* or transition sorts—the cirro-cumulus, cirro-stratus, cumulo-stratus, and nimbus. The *cirrus* or curl-cloud (the catstail of sailors) is composed of thin filaments, the association of which resembles curls of woolly hair, and at times a filmy texture of network. It is the highest of all clouds, resting all but motionless in the thin blue atmosphere; and is by some supposed to consist of frozen vapour or light flakes of snow. The *cumulus* or heap-cloud (the ball-of-cotton of sailors) is generally a spring or summer cloud, and presents itself in the form of rolling hemispherical masses resting on a horizontal base. Sometimes these hemispheres are built one upon the other, and form those great clouds which accumulate on the horizon, and resemble at a distance mountains covered with snow. The *stratus* or spread-cloud is a horizontal band, which forms at sunset and disappears at sunrise. Under the name of *cirro-cumulus* are designated those little rounded clouds which are often called woolly clouds; and when the sky is covered with them it is said to be *fleecy*. The *cirro-stratus* is composed of little bands of filaments, more compacted than those of the cirrus; for the sun has sometimes a difficulty in piercing them with his rays. These clouds form horizontal strata, which at the zenith seem composed of a great number of thin clouds; whilst at the horizon, where we see the vertical projection, a long and very narrow band is visible. When the cumulus clouds are heaped together, and become more dense, this species of cloud passes into the condition of *cumulo-stratus*, which often assumes at the horizon a black or bluish tint, and passes into the state of *nimbus*, or rain-cloud. The latter is distinguished by its uniform grey tint and its fringed edges; and the clouds of which it is composed are so compounded that it is impossible to distinguish them."]

229. The precipitation of water from the atmosphere in the form of *rain* depends chiefly on the further condensation of clouds and fogs by the commingling of colder and warmer currents. The capacity of air for moisture decreases at a faster rate than the temperature, and thus the mingling of two currents only slightly differing in temperature may so reduce this capacity, that heavy rainfalls will take place even where there is no great decrease in atmospheric warmth. Where the temperature of the air falls below the freezing-point (32° Fahr.), the atmospheric vapour may be converted into *snow*; or if rain has been already formed in the upper air, the drops in passing through strata beneath the freezing-point will be converted into *hail*. Rain, hail, and snow are thus to a certain extent convertible phenomena: hail occurring in all latitudes and climates; but snow only in the colder latitudes, and at elevations where the thermometer continues below 32°. Winds being the great natural agents by which the colder and warmer masses of the atmosphere are brought into combination, rains will occur most frequently where these currents are shifting and variable. Where the winds are constant and of equable temperature, rain seldom happens, unless at point

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232. As may be expected, the annual rainfall of these different regions will differ very widely; and will be attended, of course, by proportionate results—heavy falls being beneficial in hot countries (unless they occur with such violence as to denude the surface of its soil), and moderate supplies in temperate and milder zones. In the British Islands the annual fall (as ascertained by rain-gauge) ranges from 24 to 60 inches, or has an average of about 36 inches; while in tropical countries the mean is upwards of 200 inches. As much, however, as 229 inches has been noted in Dutch Guiana, 276 in Brazil, 302 at an elevation of 4200 feet in the Western Ghauts, south of Bombay; and in the Khasia Mountains, at the head of the river-flats or Jheels of Bengal, upwards of 600 inches, or 50 feet, have been registered by several observers. At the same place, Dr Hooker has recorded 30 inches in twenty-four hours; 21 inches have been noted at Cayenne during the same period; and 23 inches are not uncommon near Port Jackson in New South Wales.

[Referring to the excessive rainfall at Khasia, and its effects in carrying off the soil and denuding the surface, Dr Hooker, in his 'Himalayan Journal,' has the following instructive passage:—"The climate of Khasia is remarkable for the excessive rainfall. Attention was first drawn to this by Mr Yule, who stated that in the month of August 1841, 264 inches fell; and that during five successive days 30 inches fell in every twenty-four hours. Dr Thomson and I also recorded 30 inches in one day and night, and during the seven months of our stay upwards of 500 inches fell, so that the total annual fall perhaps greatly exceeded 600 inches, or 50 feet, which has been registered in succeeding years! From April 1849 to April 1850, 502 inches fell. This unparalleled amount is attributable to the abruptness of the mountains which face the Bay of Bengal, from which they are separated by 200 miles of jheels and sunderbunds. . . . The direct effect of this deluge is to raise the little streams about Churra 14 feet in as many hours, and to inundate the whole flat, from which, however, the natural drainage is so complete, as to render a tract, which in such a climate and latitude should be clothed in exuberant forest, so sterile, that no tree finds support, and there is no soil for cultivation of any kind, not even of rice; owing, however, to the hardness of the horizontally-stratified sandstone, the streams have not cut deep channels, nor have the cataracts worked far back into the cliffs. The limestone alone seems to suffer, and the turbid streams from it prove how rapidly it is becoming denuded. The great mounds of angular gravel on the Churra flat are perhaps the remains of a deposit, 50 feet thick, elsewhere washed away by these rains; and I have remarked traces of the same over many slopes of the hills around."]

233. Extending the facts alluded to in the preceding paragraphs, the rainfall of the globe may be arranged under three great heads—the periodical of the tropics; the variable of the higher latitudes; and the abnormal of certain districts where occurs either in excess or is altogether absent. Within the tropics the rainy season commences at the shifting of the monsoons; and as this change is dependent upon the position of the

sun, it begins earlier in those regions that lie near the equator than in those more remote. In general terms, the rainy season in the northern half of the torrid zone may be said to commence with April and last till October, while the dry season extends from October till April. In the southern half this order is reversed—the dry season embracing from April till October, and the season of rain from October till April. In Africa, for instance, near the equator, the wet season begins in April and continues till October; while in Senegambia it does not commence till June, and then lasts till November. In India, on the Malabar coast, the rains commence early in May, but do not reach Delhi till near the end of June. In the New World, also, the rain falls at Panama early in March, but it seldom appears in California before the middle of June.

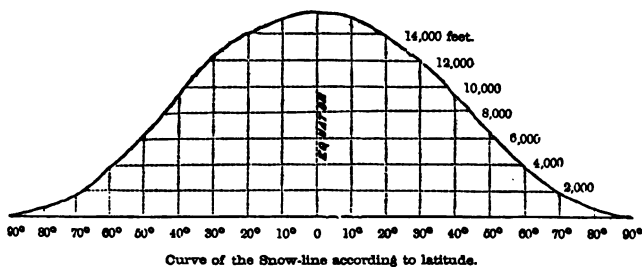
234. Commenting on the periodicity of the dry and the rainy season within the tropics, M. Guyot makes the following lucid and graphic remarks:—"Whenever the trade-wind blows with its wonted regularity, the sky preserves a constant serenity, and a deep azure blue, especially when the sun is in the opposite hemisphere; the air is dry and the atmosphere cloudless. But in proportion as the sun approaches the zenith, the trade-wind grows irregular, the sky assumes a whitish tint, it becomes overcast, clouds appear, sudden showers accompanied by fierce storms ensue. They occur more and more frequently, and turn at length into floods of rain, inundating the earth with torrents of water. The air is at this time so damp that the inhabitants are in an incessant vapour-bath. The heat is heavy and stifling, the body becomes dull and enervated: this is the period of those endemical fevers that destroy so great a number of the settlers who have come from the temperate zones. But vegetation puts on a new freshness and vigour; the desert itself becomes animated, and is overspread for a few months with enchanting verdure which furnishes pasture to thousands of animals. Nevertheless, ere long, the sun in his annual progress advances to pour down his vertical rays upon other places; the rains diminish, the atmosphere becomes once more serene, the trade-wind resumes its regularity, and the heaven shuts its windows once again until the following season. Such is the normal course of the tropical rains. They fall everywhere during the passage of the sun through the zenith. The heat is then so violent that the ascending current neutralises the horizontal trade-wind. It hurries the vapours to the heights of the atmosphere and the upper limit of the trade-wind, where they are condensed and fall back in a deluge of rain."

235. Of course, within the tropics as elsewhere, the regularity

of the periodical rains is interrupted by the configuration of the land, mountain-chains, and similar causes; hence the peculiarities that mark the times as well as intensities of the wet and dry seasons of such areas as the east coast of Africa, the Red Sea, the Malabar coast, the Coromandel coast, and the coasts of Australia. On the Malabar coast, for example, the south-west monsoon (coming from the humid region of the equatorial ocean to supply the place of the highly rarefied air of the heated continent) is said to be "ushered in by terrific storms of thunder and lightning. The water pours down in torrents, and when the thunder has ceased, nothing is heard for several days but the rush of the descending rain, and the roar of the swelling streams. In a few days the storm ceases, and the earth, which before was withered by the glowing atmosphere of the dry season, is now, as if by magic, suddenly clothed with the richest verdure; the air above floats pure and balmy, and bright tropical clouds sail tranquilly through the sky. After this, the rains fall at intervals for the space of a month, when they again return with great violence. In July they attain their height, and from that time gradually subside until the end of September, when the season closes, as it began, in thunders and tempests." On the eastern, or Coromandel side, the order of things is reversed. The south-west monsoon, in passing over the Western Ghats and the central table-land of the Deccan, parts with all its moisture, and reaches the eastern side as a hot, dry wind; and it is not till the north-east monsoon begins to prevail in October that the rainy season is experienced on the coast of Coromandel.

236. Beyond the tropics the rains no longer occur at stated periods, but become *variable*—that is, are distributed throughout the year in a very irregular and uncertain manner. In some countries they occur most frequently in winter; in some, in spring and autumn; and in others, again, most abundantly in summer. Thus, the amount that falls in the west of England in winter is said to be eight times greater than that in summer; in Germany the winter and summer amounts are about equal; but in St Petersburg the winter fall is little more than a third of what descends in summer. Again, in Britain, there are more rainy days in winter than in summer; but in Siberia it rains four times as often in summer as in winter. The countries of Europe bordering the Mediterranean are generally regions of winter rains; while those of west Europe are distinguished rather by the abundance of their tumnal rains. In Europe north of the Alps, the north-east winds (as coming from the higher and colder latitudes) are comparatively dry; while those from the south-west (from the humid expan-

that descends from the atmosphere when the temperature of the air at the surface of the earth is near or below the freezing point of water. Of course, at the sea-level within the tropics, and for fifteen or twenty degrees beyond them in either hemisphere, snow is unknown (see Rain and Snow Map in Atlas); and it is only during winter that it falls in the higher latitudes, and at considerable elevations. In the polar regions, and at extreme heights in all latitudes, it becomes perennial; and this limit at which it remains unaffected by the heat of summer is known as the *snow-line*, or, less accurately perhaps, as the line of *perpetual congelation*. The lower the latitude—that is, nearer the equator—the higher the snow-line, which descends constantly, but somewhat irregularly, according to the nature of the situation, as we proceed towards either pole. The following diagram will convey some idea of its gradual descent from 16,000 feet at the equator



down to the sea-level at the poles. From the equator to latitude 30° there is little variation in the height of the snow-line, unless there be some peculiarity as regards winds and moisture in the situation; but from 30° to 60° the descent is very rapid, and the limit rapidly approaches the sea-level, as was formerly noted in Chap. VI., on Mountains and Mountain-Systems. As hoar-frost may be said to be frozen dew, and snow frozen mist, so *hail* may be described as frozen rain. It occurs in all latitudes and at all seasons; and though the producing causes are not always discernible, it seems mainly dependent on the meeting of aerial currents of greatly unequal temperatures, as well as on peculiar electric¹ conditions of the atmosphere. Falling in pellets from the size of a pea to that of a pigeon's egg, hail-storms are frequently destructive, but luckily are always restricted to limited areas of short duration. *Sleet*, which is an admixture of snow rain, or of small particles of hail and rain, generally occurs during squally weather in spring and autumn, and seems to i.

HYDROLOGY.

the rain from one, mountain-ridges above the polar lands within will become more or less greatly augmented by the falling and From this accumulation of avalanches, glaciers (Fr.) which are from lofty mountains and plains begin to descend for the declivity its adhesion to accumulations of and ravines of on boreal up towards partly of the freezing with a peculiar which they pass, and as they terminal, as they as ice-streams melt and disappear the entire surface, losing are floated away The true limited phenomenon something the latter the surface of discharging the ocean the ice above some idea of their a tenth of ice being of boulders "pucks" and "pucks"

of such ice are familiar phenomena both in arctic and antarctic waters—the bergs of the north being seldom carried southward in the Atlantic beyond the 44th parallel of latitude, while those of the south are not unfrequently found northward as far as the Cape of Good Hope, or, on an average, at 10 degrees lower latitude.

240. As climatological agents, snow and ice have considerable influence on the regions in which they occur. Accumulating on mountain-heights, they are the perennial sources of the springs and streams that descend to refresh and fertilise the thirsty lowlands; while in tropical countries the winds that pass over them are cooled, and flow downwards to temper the sultry atmosphere of the plains below. Masses of floating ice are productive of similar results, the seas and coasts in their vicinity being cooled by their presence, and fogs and rain-storms generated as they melt away. In the higher latitudes, on the other hand, where the winters are severe, snow forms a warm covering for the soil (the *snow-blanket*, as it is termed by farmers), and greatly defends vegetation from the rigour of the frost. Within the polar circle, also, the darkness of the long winter is considerably diminished by the *snow-sheen* or *snow-blink*—snow reflecting, instead of absorbing like the bare ground, the faint light that there proceeds from the sky. The grinding, grooving, and smoothing effects of glaciers on rock-surfaces, and the rock-transporting powers of icebergs, are facts now well known to Geology; and though their consideration belongs more immediately to that science, the results now and in time past cannot be altogether overlooked by the student of Physical Geography.

Causes affecting Climate.

241. In its technical sense, the term *climate* (Gr. *klima*, an inclination) denotes an imaginary belt of the globe parallel to the equator, and so called by the earlier geographers, because the differences of these climes depend on the inclination or obliquity of the sphere. Between the equator and the polar circle there were twenty-four such climatic belts—each depending on the increasing length of the day (half an hour's increase for each belt) and of course expanding in breadth from the equator toward poles. From the polar circles to the poles there were six—the differences of the longest day in their case being at monthly periods instead of half-hours. The term is now employed in a much wider sense, as embracing the entire *weather conditions* of any district, and as such we shall now proceed

Such is the general climatic order as regards latitude; though, owing to the smaller extent of land, the decrease of heat as we depart from the equator is more rapid in the southern than in the northern hemisphere—so that, on a general average, the latter is about $3\frac{1}{2}^{\circ}$ warmer than the former.

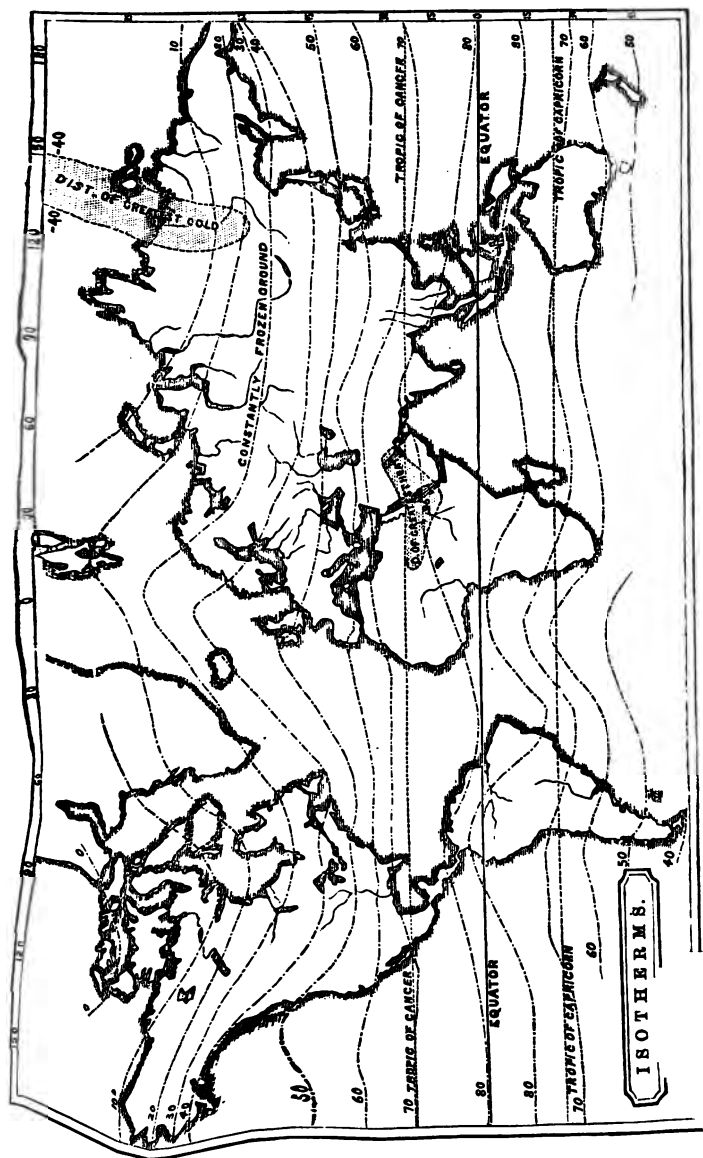
243. Altitude is the next great modifier of climate, but owing to many correlative circumstances (prevalent winds, slope, proximity to the sea, &c.), its operation is not altogether uniform. As formerly stated, a decrease of 1° Fahr. takes place in the lower regions of the atmosphere for every 300 or 350 feet of ascent; but at great heights and in extreme latitudes the decrease is more rapid. As it is, under every latitude the loftier mountains (Himalayas, Alps, Andes, &c.) are perpetually covered with snow; the higher plateaux (Mexico, Bolivia, Armenia, Tibet, &c.) are several degrees colder than the contiguous lowlands; and in temperate zones such table-lands experience much greater extremes of summer's heat and winter's cold than the surrounding districts—having, like Spain, Armenia, and Persia, summers of tropical heat and winters of almost polar severity. Another great cause of modification is the unequal reception and radiation of heat by land and water (par. 206), by which islands and sea-coasts are rendered cooler in summer and warmer in winter than inland tracts—creating what has been termed *insular* and *continental climates*. Britain, New Zealand, and Tasmania enjoy, in this respect, insular climates; Germany, central Russia, and Tartary, continental ones. Connected with this, and depending on the set of the trade-winds and ocean-currents, may be noticed the observation of Humboldt, that the continents and larger islands in the northern hemisphere are warmer on their western than on their eastern sides; while in the southern hemisphere the reverse holds good—the western being the colder and the eastern the warmer.

244. It would exceed the limits of a text-book to describe in detail the many causes concerned in the modification of climates; but besides those of latitude, altitude, and proximity to the sea, we may notice the following:—1. The direction of mountain-ranges, which, by intercepting cold winds, renders the countries on the windward side warmer than those on the other; and in like manner, prevailing moist winds, favours the production of rain on the windward slopes and droughts on the leeward or sheltered declivities. The eastern slopes of the Andes, for example, intercept the trade-winds from the Atlantic; their counter-slopes on the western side are arid and rainless. 2. The general inclination of the land, as this may lie to the heat of the morning sun, or be turned to the feebler rays of his afternoon and

evening declension. 3. Owing to their different capacities for heat, the relative masses and configuration of the land and water greatly affect the climatic peculiarities of a country: and this as moist and warm winds generally come from the sea, while cold and dry ones blow from the land—as the seaboard has a moist and cloudy sky that prevents radiation, while the interior has a serene sky that favours it and lowers the temperature—and as this radiation is greater in summer than in winter, and consequently interferes with the amount of heat directly received from the sun. 4. The prevailing winds of a region, as these may be cold or warm, dry or humid. The westerly winds of our own island are humid and warm—the easterly are cold and dry; hence the greater rainfall and mildness of our western coasts as compared with the eastern. 5. As with winds, so in like manner with the influence of oceanic currents. The Gulf Stream, by bringing warmth and moisture, mitigates the winter climate of western Europe; the Arctic current, on the other hand, tempers the summer climate of the eastern shores of North America. 6. The direction of river-plains and valleys, as they open out to favourable winds and ocean-currents. The westerly reception of the Rhine basin produces a finer climate than the easterly trend of the Danube, even though the latter be several degrees farther south; and the southerly slope of the valley of the Rhone enjoys amenities unknown in the westwardly-trending basins of the Loire and Garonne. 7. Cultivation has also a marked effect on the climate of a country—the felling of forests, draining of lakes and morasses, and the like, being all favourable to greater dryness, warmth, and general amenity.

Lines of Equal Heat, &c.

245. Under circumstances mentioned in the preceding paragraphs, it will readily be perceived that the belts of climate can by no means correspond with the parallels of latitude, but that it requires a long series of observations to determine the *seasonal temperatures* of summer and winter, and also a careful average of these to ascertain the *mean yearly temperature* of any given locality. If the surface of the globe had been all water, or all land of equal altitude, the parallels of latitude would have determined the lines of climate; but this not being the case, the daily temperature, the summer and winter temperatures, as well as the mean annual temperature of any two places in the same latitude, differ considerably. In this way the maximum



summer heat of an island may be several degrees below that of a continental country between the same parallels, while its winter temperature is many degrees higher. In this way, also, the mean annual temperature of some island or sea-coast may be equal to that of some inland district situated several degrees nearer the equator. A series of lines drawn through places having the same summer temperature show these variations at a glance, and are termed *isothēral lines* (Gr. *isos*, equal, and *theros*, summer), or lines of equal summer heat; those through places having the same winter temperature, *isocheimōnal lines* (Gr. *isos*, and *cheimon*, *cheimōnos*, winter); and those connecting places of the same mean annual temperature, *isothermal lines* (Gr. *isos*, and *therme*, heat). The difference between the summer and winter temperatures may amount to 2°, 20°, 40°, or more degrees of Fahrenheit; but the isothermal lines show the mean amount of heat received throughout the year, and, of course, are the more correct indicators of the general climatic conditions of any given locality. In the accompanying Sketch-Map the isotherms are laid down for every ten degrees, and their bendings northward and southward (according to distribution of land and water, altitude, distance from sea, &c.) convey to the eye instructive proofs of the operating causes adverted to in the foregoing paragraphs.

[In amplification of the preceding remarks on Climatology, the following passage from Mrs Somerville may be read by the student with advantage:—"Places having the same mean annual temperature often differ materially in climate. In some the winters are mild and the summers cool, whereas in others the extremes of heat and cold prevail. England is an example of the first; Quebec, St Petersburg, and the arctic regions are instances of the second. The solar heat penetrates more abundantly and deeper into the sea than into the land; in winter it preserves a considerable portion of that which it receives in summer, and from its saltness does not freeze so soon as fresh water; hence the ocean is not liable to the same changes of temperature as the land, and by imparting its heat to the winds it diminishes the severity of the climate on the coasts and in islands, which are never subject to such extremes of temperature as are experienced in the interior of continents. The difference between the influence of sea and land is strikingly exemplified in the high latitudes of the two hemispheres. In consequence of the unbounded extent of the ocean in the south, the air is so mild and moist that a rich vegetation covers the ground, while in the corresponding latitudes in the north the country is barren from the excess of land towards the Polar Ocean, which renders the air dry and cold. A superabundance of land in the equatorial regions, on the contrary, raises the temperature, while the sea tempers it.

"Professor Dove has shown from a comparison of observations that northern and central Asia have what may be termed a true continental climate both in summer and in winter—that is to say, a hot summer and cold winter; that Europe has a true insular or sea climate in both seasons, the summers being cool and the winters mild; and that in North America the climate is inclined to be continental in winter, and insular in summer. The extremes of temperature in the year are greater in central Asia than in North America, and greater in North America than in Europe,

and that difference increases everywhere with the latitude. In Guiana, within the tropics, the difference between the hottest and coldest months in the year is only $2^{\circ}.2$ Fahr., in the temperate zone it is about 60° , and at Yakutsk, in Siberia, $114^{\circ}.4$. Even in places which have the same latitude, as in northern Asia compared with others in Europe or North America, the difference is very great. At Quebec the summers are as warm as those in Paris, and grapes sometimes ripen in the open air, yet the winters are as severe as those in St Petersburg. In short, lines drawn on a map through places having the same mean summer or winter temperature are neither parallel to one another, nor to the isothermal or geothermal lines, and they differ still more from the parallels of latitude."]

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters attention has been directed to the Climatology of the globe—that is, to those weather-conditions on which its vegetable and animal life are so intimately dependent. The main medium of climate being the Atmosphere, it was necessary to advert to its nature and composition as an integral portion of our planet. As an aerial fluid, it consists of an admixture of 79 parts nitrogen and 21 oxygen, together with a small but variable proportion of carbonic acid gas, traces of ammonia, &c., and always holding in suspension less or more of aqueous vapour in a visible or invisible form. Constituted as plants and animals are, this composition is indispensable to their existence—the former assimilating carbonic acid and exhaling oxygen, the latter, in counterbalance, exhaling carbonic acid gas and consuming oxygen. Light and invisible as this aerial envelope may appear, it exerts a pressure on the earth's surface, at the sea-level, of about $14\frac{1}{2}$ lb. avoirdupois to the square inch—a pressure which is balanced by a column of mercury 30 inches in height; hence the *barometric column* of the meteorologist, and the *rise and fall of the barometer* according to changes in the weight of the atmosphere. As an elastic or compressible medium, its lower strata are denser or heavier than those at great elevations; and as its capacity for heat and moisture decreases with its rarity or attenuation, the higher regions of the air are colder and drier than those at a low elevation.

As the medium through which the light and heat of the sun are conveyed to the terraqueous surface, the atmosphere partly owing to the varying inclination of the sun's rays, and partly to the unequal reception and radiation of heat by land and water—becomes variously heated in its different regions, and

which snow remains unaffected by the heat of summer (the *snow-line*) varies with the latitude—descending from 14,000 or 15,000 feet at the equator to near the sea-level at either pole. The altitudinal limit, north and south (the *snow-limit*), varies also according to the distribution of sea and land—receding and advancing as either element prevails. The perpetual presence of snow and ice on lofty mountain-ridges and polar uplands gives rise to *avalanches*, *glaciers*, and *icebergs*—phenomena whose geological influences are not less apparent than their climatological.

The causes which affect the *climate* or weather-conditions of any locality are thus extremely varied—latitude, altitude, distribution of land and water, proximity to the sea, prevalent winds, direction of mountain-chains, slope, nature of soil, cultivation, and so on like, all more or less exerting their modifying influences. Heat and moisture, however, are the great regulators of climate; and thus, in general terms, climatological zones may be said to increase in importance from the equator to the poles. Nevertheless, this decrease by no means coincides with the parallels of latitude; hence to determine the mean temperature of any locality, numerous thermometrical observations have to be made at hourly, daily, monthly, and yearly intervals. The results of such observations enable the meteorologist to connect places having the same summer, winter, and mean annual temperatures; and hence the convenience of exhibiting them at a glance by means of *isothermal*, *isothermonal* or *isocheimal*, *isothermal*, and other lines.

To the student who would enter more fully into the consideration of the atmosphere and its phenomena, and especially into the subject of climatology as affecting the plant-life and animal-life of the globe, we would recommend perusal of some treatise on meteorology, as that by Professor Kaemtz (an English translation of which appeared in 1845); the essay by Sir John Herschel, which has been republished from the 'Encyclopædia Britannica'; Dr Thomson's 'Elements'; or the still briefer and simpler compilation of Professor Brocklesby of Hartford, U.S.—a work of much greater merit than pretension.

STRUCTURE AND FUNCTION.

of the Land, Water, and Atmosphere, and the phenomena arising therefrom, which they are respectively associated with the inorganic phases of the earth. In the former we deal with the mere chemistry of chemical and physical changes. Now we have to deal with the changes occurring through peculiar relations of matter and relations of nature to the inorganic and organic constituents of the earth. The term Life is embraced within the domain of the natural kingdoms—subdivided into Botany and Zoology, and includes all the phenomena of life as far as they are dependent on the physical conditions of their position or distribution in the world. The laws, causes, and functions of Life form the domain of Biology, in which their internal and external relations become important considerations in the study of Physical Geography.

trial and aërial—into flowering and flowerless—into trees, shrubs, herbs, grasses, mosses, lichens, sea-weeds, &c.—belongs to the province of Botany; and of animals into aquatic, terrestrial, and amphibious—into mammals, birds, reptiles, fishes, shell-fish, &c.—belongs in like manner to the province of Zoology. What the geographer has more especially to consider is their distribution over certain areas, the physical conditions apparently concerned in their restriction to these areas, and the dependence of the one kingdom upon the other, as completing the economy of nature. As it is Life that gives to creation its highest interest, so the consideration of its relations becomes the highest theme of our subject. For the sake of brevity, the term *flora* (Lat.) is employed to designate the plant-life of a region or epoch, and the term *fauna* its animal-life; hence we speak of the “Flora of South America” and the “Fauna of South America,” as well as of the Flora and Fauna of the Tertiary, the Chalk, or any other geological period.

248. So far as the eye, or the eye aided by the microscope, can perceive, life is everywhere present—in the air, on the earth, and in the water, or even parasitic on and within other plants and animals. Unless, perhaps, among the perpetual snows and ices of the poles and lofty mountain-peaks, or in the extreme depths of the ocean, its manifestations are sufficiently apparent; and even in these situations some forms unknown to observation may find a permanent or temporary home. And yet, universal as life may appear, it is confined to the merest film of the terraqueous globe. A few thousand feet above the sea-level on land, and a few thousand feet beneath it in the waters, limit this *stratum of life* on either hand. Thickest at the equator, it thins out towards the poles; and densest near the sea-level, it becomes rarer and rarer the more it rises above or falls beneath this line of greatest intensity. Heat, light, moisture, and nature of soil are the great regulators of life on the land; heat, light, depth, nature of bottom, and saline composition, the main regulators in the ocean. Were it not for these causes there is no reason why the same forms of life should not prevail in every region from the equator to the poles, and from the shore-line to the darkest abysses of the ocean. The influence, however, of external conditions is insuperable: the palm of the tropics would dwarf and die in the temperate zone; the whale of the Greenland seas would perish in the waters of the equator; the rush that luxuriates in the marsh would wither transferred to the arid upland; the shell-fish that swarms in the influence of the tides would die if submerged to the depth of a few hundred fathoms; the fresh water that forms the vital element

... of the land... of another that has been
... of the ocean.

... therefore, adapted by
... that position con-
... and within that position con-
... the surrounding conditions
... should differ from
... at all events, the im-
... and not to that of
... should only appear in cer-
... the ostrich
... in Australia, the ostrich
... in Africa and the llama in South America—while other regions
... is a question involving
... of land and
... What more im-
... distribution of
... that distribution,
... and the question how far they are capable of being transferred to,
... and acclimatised in other districts for the luxury and necessities
... of man. These are the subjects of importance to the merchant,
... the determination of the regions of supply,
... the amount and quality of products, and the possibility of the pro-
... the plants or animals in other
... countries than those which they naturally occupy.

250. Some tribes have naturally a wider range than others;
... have a more elastic constitution, and are capable of
... of climate; and others, obeying the
... migrate from the unfavourable

... to the favourable season of another. Of all
... his superior intelligence
... the widest range—his superior intelligence
... to modify and overcome conditions that would be
... of the domesticated
... Many, however, of the domesticated
... and cultivated plants have also considerable elasticity of
... and thus man has been enabled to carry them along

... the greater part of the habitable globe. In this
... distinguish between the truly indigenous or
... a country, and the exotic or imported, though
... have been so long transferred and re-transferred
... impossible to point to their original habitats
... there is a natural apportioning of plants and
... certain areas, and while external conditions are re-
... main regulators of this distribution, it must ever be
... that man has already modified, and is continually
... distribution by transferring, cultivating, and de-
... as his wants and wishes may compel. His

operations, however, can never extend beyond a mere modification; for over and above his control remain the great conditions of heat, light, moisture, &c., which ever govern the main geographical arrangements of plants and animals; and it is to these in particular that the limits of a text-book will permit us to refer.

Plant-Life—its Distribution and Governing Conditions.

251. As already mentioned, heat, light, and moisture are the principal conditions affecting the terrestrial distribution of vegetable life. These conditions have their greatest intensity near the equator; hence the greatest exuberance of vegetation within the tropics, and its gradual declension as we proceed towards either pole. As might be anticipated, however, this declension is governed more by the isotherms than by the parallels of latitude—the mean amount of annual heat being the predominant condition in vegetable distribution, though the amount of summer heat (isothermal) has also much to do with its ripening and perfection. The mean annual temperature of two places may be the same, and yet the summer temperature of the one may be 10° higher than that of the other, while the winter temperature may be 15° or even 20° lower. Much, therefore, in Botanical Geography depends upon the amount of heat which a plant receives during the period of its greatest activity, and this, in general, is regulated more by the monthly than by the annual isotherms. The zones of vegetation shading more gradually into each other than the astronomical zones (torrid, temperate, and frigid), botanists make a minuter subdivision of the earth's surface into equatorial, tropical, sub-tropical, warmer-temperate, colder-temperate, sub-arctic, arctic, and polar—each characterised by some peculiar feature, though partaking on either side of the forms that belong to the two adjacent zones.

252. The *equatorial* zone, bounded by the isotherm of 79° , is characterised, wherever moisture is present, by its luxuriant vegetation. It embraces the central regions of Africa from shore to shore, the southern portion of the Indian peninsula, the Malayan Archipelago, the northernmost parts of Australia, and other Pacific islands in the same latitude. In equatorial South America, including Colombia and the northern parts of Brazil. Succulent flowers, gigantic parasites and climbers, arborescent plants, bamboos, &c.), orchids, palms, bananas, bread-fruit trees, silk-cottons, banians, Adansonia, and

like, are typical of this belt, the greater portion of which, for reasons given in the preceding chapter, lies to the north of the equator.

253. The *tropical zones*, extending to the isotherms of $73\frac{1}{2}^{\circ}$ on either side of the equator, include, in the New World, Bolivia, Brazil, and Paraguay in the southern hemisphere, and the West Indies, Yucatan, Guatemala, and part of Mexico in the northern; while in the Old World it embraces Nubia, Senegambia, Madagascar, Mauritius, and North Australia in the southern hemisphere, and South Arabia, India, Burmah, and southern China in the northern. These zones are characterised by palms, bananas, pine-apples, tree-ferns, species of fig, pepper-shrubs, cinnamon, indigo, cotton, coffee, sugar-cane, &c.—there being fewer parasites, and more underwood in the forests. And it has been further remarked by the botanist, that as palms and bananas may be said to mark the equatorial zone, so may arborescent ferns and species of fig be said to predominate in the tropical.

254. The *sub-tropical*, bounded by the isotherm of 63° , embrace Southern Africa and Australia, Paraguay, La Plata, and Chili in the southern hemisphere; and North Africa, Egypt, Syria, North Arabia, Persia, Northern India, part of China, the Southern States of North America, Mexico, and California in the northern hemisphere. They are characterised by a luxuriant growth of magnolias, laurels, myrtles, and figs, together with certain palms, zamias, cactuses, and arborescent euphorbias. In these zones, as in the damp regions of the preceding belts, vegetation is green throughout the year, and the climate, unless where rainless, is described as delightful. They are pre-eminently the lands of the laurel and myrtle.

255. The *warmer-temperate*, limited by $53\frac{1}{2}^{\circ}$, are still regions of evergreens, but are marked by the absence of palms—the dwarf palm of Europe, the palmetto of North America, and the Chilean palm, being, as it were, outlying forms from the sub-tropical zone. Deciduous forest-trees, oaks, chestnuts, &c., and figs, oranges, pomegranates, olives, and the vine, are typical of the warmer-temperate in the northern hemisphere; shrubby ferns, arborescent grasses, and araucariæ in the southern. This “region of evergreen trees,” as it has been called, embraces the well-known flora of southern Europe, as well as those of Asia Minor, the north of China, and Japan.

256. The *colder-temperate*, bounded by the mean annual temperature or isotherm of $42\frac{1}{2}^{\circ}$, is, in the northern hemisphere, the great zone of deciduous forest-trees, or those which shed their leaves in winter—hence the seasonal contrasts unknown in warmer regions. The characteristic vegetation of this zone is well seen in

that of our own country, the north of France, and Germany—forests of coniferous trees (fir, pine, yew, &c.) and expanses of heath adding peculiar features to the area. The cultivation of wheat scarcely extends beyond this zone in the northern hemisphere; in the southern it is occupied chiefly by the ocean—Tierra del Fuego, Falkland Islands, and Kerguelen's Land being the only important portions.

257. The *sub-arctic* zone, limited by the isotherm of 39° , is characterised by coniferous trees (pine, larch, spruce, juniper, &c.), poplar, beech, grasses, and heaths; and, on its northern limits, by birch, willow, and alder, which become dwarfed, and never attain to the size of trees. "This zone," says Professor Balfour, "is of less extent than the preceding, and in the interior of Asia it is perhaps not so easily distinguishable from it as in Europe. In the northern hemisphere it is the zone of firs and willows; in the southern it embraces a few barren islands. The northern parts of Siberia and Norway, the Farøe Islands, and Iceland belong to this zone. In the Farøe Islands barley does not always ripen, but the turnip and potato generally succeed. The Amentifere (plants bearing catkins) in these as well as in Iceland do not become trees. Grasses, common heath, and juniper, form features in the physiognomy of Iceland; in Siberia, forests of pine, larch, spruce, poplar, and birch occur."

258. The *arctic* zone (which has no equivalent in the southern hemisphere, where the ocean alone prevails) is marked by the dwarf birch, alder, and willow; by occasional pines and firs; by grasses; and by numerous lichens and mosses on its northern limits. At Hammerfest, in lat. 71° , according to the authority just quoted, potatoes, turnips, cabbage, and carrots generally succeed. In the American section, rhododendron, andromeda, and azalea are not unfrequent.

259. The *polar* zone is characterised chiefly by its flowerless plants—lichens and mosses—though, during its brief summer, species of ranunculus, saxifrage, scurvy-grass, rush, willow, &c., make their appearance. In this zone there are no trees nor bushes, nor any cultivation of plants for food. In the cold zones it has been remarked that there are more genera and fewer species than while the species are few, the individuals are numerous.

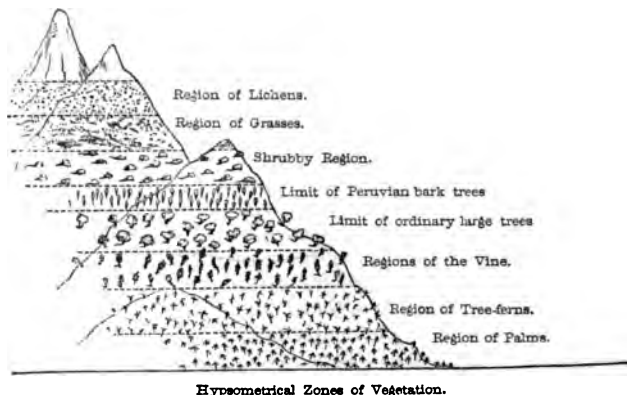
260. Such, in general terms, is the characteristic distribution of vegetable life as we proceed from warmer to colder latitudes. The student is already familiar with the fact that temperature decreases not only as we proceed from the equator towards the poles, but also as we ascend from the level of the sea into the high regions of the atmosphere. This ascent—*hyposymmetrical*, as it

[The page contains approximately 40 lines of text that are almost entirely illegible due to extreme blurring and heavy noise. The text appears to be a continuous block of prose, possibly a letter or a report, but no specific words or phrases can be discerned.]

horse-chestnut, elm, maple, pine, yew, hazel (growing to a large tree), and many others. At about 11,500 feet the forest ends—Webb's pine and the Bhojatan birch being usually the last trees. Shrubs continue in abundance for about 1000 feet more; and about 12,000 feet the vegetation becomes almost entirely herbaceous. On the southern face of the mountains the snow-line is probably at an elevation of 15,500 feet. The highest dicotyledonous plant noticed was at about 17,500 feet, probably a species of *Chinospermum*. A nettle, also, is common at these heights. The snow-line here recedes to 18,500 or 19,000 feet. In Tibet itself the vegetation is scanty in the extreme, consisting chiefly of *Caragana*, species of *artemisia*, *potentilla*, and a few grasses. The cultivation of barley extends to 14,000 feet. Turnips and radishes, on rare occasions, are cultivated at nearly 16,000 feet. Vegetation ends at 17,500 feet: scanty pasturage being found only in favoured localities at this elevation; and the highest flowering plants are *Corydalis*, *cruciferae*, *sedum*, and a few others."

262. In temperate latitudes, though the variety of vegetation becomes less, and the lower zones of tropical flora be necessarily wanting, similar phenomena present themselves. "We may begin the ascent of the Alps, for instance, in the midst of warm vineyards, and pass through a succession of oaks, sweet chestnuts, and beeches, till we gain the elevation of the more hardy pines and stunted birches, and tread on pastures fringed by borders of perpetual snow. At the height of 1950 feet the vine disappears; and at 1000 feet higher the sweet chestnuts cease to thrive; 1000 feet farther, and the oak is unable to maintain itself; the birch ceases to grow at an elevation of 4680 feet; and the spruce fir at the height of 5900 feet, beyond which no tree appears. The *rhododendron* then covers immense tracts to the height of 7800 feet; and the herbaceous willow creeps 200 or 300 feet higher, accompanied by a few saxifrages, gentians, and grasses; while lichens and mosses struggle up to the imperishable barrier of eternal snow." On the Pyrenees, in like manner, the following belts have been observed:—1. The zone of vine and maize cultivation, and of the chestnut woods. 2. A zone extending from the limit of the vine to about 4200 feet, at which limit the cultivation ceases; here we meet with box, saxifrage, gum, &c. 3. From the limit of the cultivation of esculent vegetables at 4200 feet to the limit of the spruce-fir. 4. From the limit of the spruce fir to 7200 feet, characterised by the presence of the *Scirpus*. 5. From 7200 to 8400 feet is an Alpine zone, characterised by dwarf juniper, *Saxifraga bryoides*, *Soldanella alpina*, *Juncus*, *fidus*, &c. 6. A zone above 8400 feet exhibits a few *Al-*

species, as *Ranunculus glacialis*, *Draba nivalis*, *Stellaria ceras-toides*, *Androsace alpina*, and *Saxifraga Gröenlandica*. The accompanying sketch exhibits, in general terms, the order of these ascending zones of vegetation, from the sea-level at the equator to the limit of perpetual snow.



Hypsometrical Zones of Vegetation.

263. Besides the great governing conditions of temperature, as dependent on latitude and altitude, there are others arising from light, slope, nature of soil, moisture, &c., which, though less general, are nevertheless equally imperative. The southern slopes of a mountain-range, exposed to the full influence of the sun's rays, exhibit not only a greater profusion of foliage and blossom, but a greater variety of species than is to be found on the northern and darker side. Even the southern side of a tree will make a larger amount of annual growth, and present a greater exuberance of flower and fruit than the northern. And yet, though heat and light are so indispensable in the economy of vegetable life, influencing their luxuriance, colours, and secretions, it must be remembered that while some families require full exposure to these influences, others luxuriate only in the shade. Nor must it be forgotten, as already noticed under Climatology, that the *quality* of the sun's rays is affected alike by altitude and the nature of the atmosphere (clear, or dense and foggy) through which they pass; and hence the difference of their influence on plants and animals. "The chemical rays of the spectrum," says Sir J. Herschel, "are powerfully absorbed in passing through the atmosphere, and the effect of their greater abundance aloft is shown in the superior brilliancy of colour in the flowers of Alpine regions." As to the

effects of density, or pressure at great heights, it is questionable whether it is at all appreciable—the diminished temperature at such altitudes being the main cause of change in the plant-life of such situations.

264. Again, the influence of soil is equally observable: hence we seek in vain on the clayey moorland for the species that form the rich and verdant carpeting of the calcareous district; or on the thirsty sand-dunes by the sea-shore for the flora that flourishes so freely on the alluvial meadow. This influence arises, of course, partly from the mere mechanical nature of the soil, and its capabilities of retaining heat and moisture, and partly also from chemical composition—the plant deriving therefrom certain ingredients which are necessary to the healthful growth and elaboration of its tissues and secretions. Every geologist has noted the difference of vegetation on the different rock-formations of a country, each belt of limestone or clay, of granite or trap-rock, being characterised by a predominance and luxuriance of certain species. Further, some plants are truly littoral, and flourish only (like the mangrove and cocoa-palm) within the influence of the sea-spray; while others become stunted and diseased if exposed, even for a season, to the breath of the sea-breeze.

265. The effect of moisture on the distribution of vegetation is direct and perceptible, arid tracts being comparatively barren, while humid regions, and especially humid and warm ones, are noted for their luxuriance. Even in tropical countries, like South America, the dry season is one of torpidity, and corresponds to the winter of temperate zones—vegetation being dormant till the rainy season returns and once more renews its growth and foliage. It is owing to this influence of moisture that botanists distinguish between rainy and rainless regions, and between zones of summer rains, winter rains, and rains at all seasons—each zone being stamped by its own vegetable aspects. But beyond this common influence of moisture on all vegetable forms, there is a natural adaptation of certain forms to moist situations; and for this reason we have plants—some inhabiting the sea, others lakes and rivers, and some, again, the marsh and mudflat.

266. As plants have a fixed and natural distribution on land, so also they have a similar distribution, horizontal and vertical, in the waters; though, in consequence of the greater uniformity of temperature, the marine areas are less marked and decided. *Horizontally*, the ocean has been divided into certain botanical provinces, of which our limits will merely permit the enumeration: 1. The Northern Ocean, from the pole to the 60th parallel;

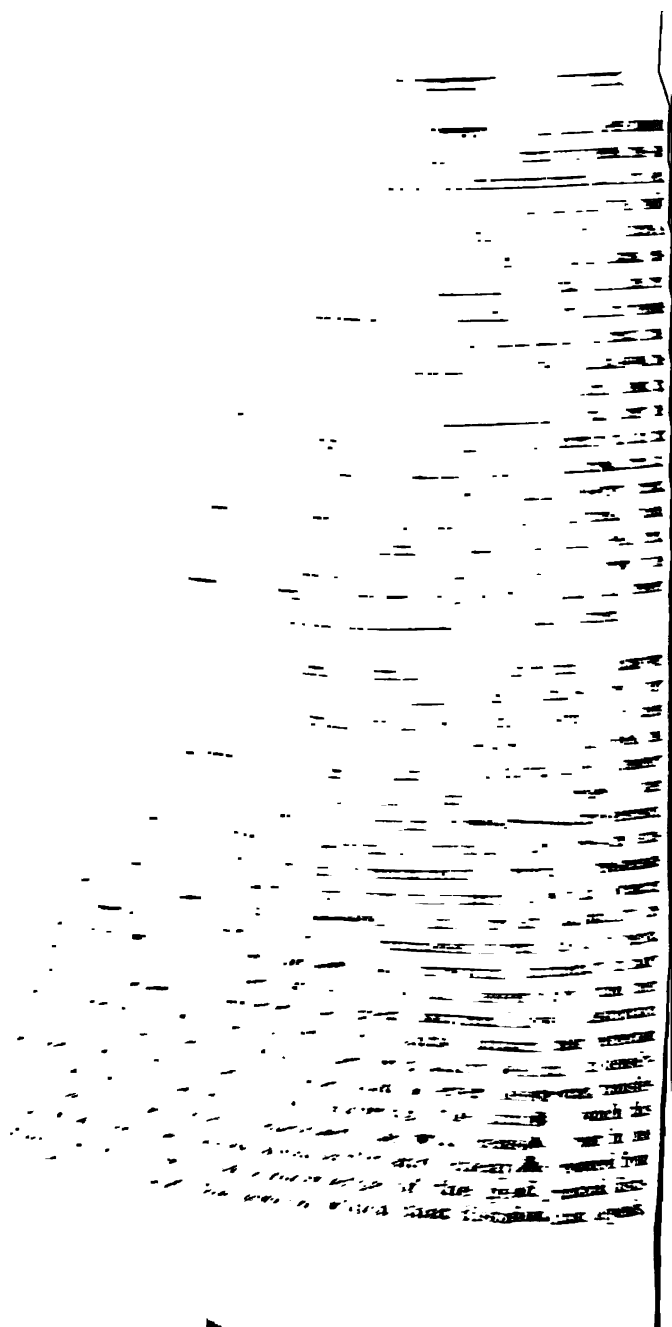
2. The North Atlantic, between the 60th and 40th parallels—the great headquarters of *Fucus* proper; 3. The Mediterranean—a sub-region of the warmer-temperate zone of the Atlantic, lying between the 40th and 23d parallels; 4. The tropical Atlantic, in which *Sargassum* abounds (Sargasso Sea, par. 139); 5. The Antarctic American regions, from Chili to Cape Horn, and the whole circumpolar ocean south of 50° of S. latitude; 6. The Australian and New Zealand; 7. The Indian Ocean and Red Sea; 8. The Japan and China Seas, besides certain less decided provinces in the Pacific.

267. *Vertically*, or *bathymetrically*, as it is termed when treating of the ocean (Gr. *bathys*, deep; *metron*, a measure), light, depth, and nature of sea-bed seem to be the prime regulators of aquatic vegetation. In the limited areas of streams and fresh-water lakes the order of arrangement is less perceptible, but in the ocean each gradually-deepening zone is characterised by its own peculiar forms. Thus, in the British seas naturalists speak of a littoral, laminarian, coralline, and coral zone; and in the ocean generally, of a littoral, circum-littoral, median, infra-median, and abyssal or deep-sea zone. The nature of these bathymetrical subdivisions will be best understood by referring to our own shores, where the *littoral* is that which lies between high and low water mark, and is characterised by such plants as the bladder-wrack, dulse, and cariceen; the *laminarian*, that which commences at low-water mark, and extends to a depth of from 40 to 60 feet, and marked, as its name implies, by the broad waving tangle (*laminaria*), and larger algæ; the *coralline*, that which extends from 90 to about 300 feet in depth, and where corallines luxuriate, and the common sea-weeds disappear; and the *coral zone*, which lies between 300 and 600 feet, and is the region of the calcareous and stronger corals. In the abysses of the ocean diatoms (microscopic vegetable forms) alone occur; and generally as the corallines increase the true sea-weeds disappear, ordinary algæ scarcely existing beyond a depth of 300 feet.

268. Admitting, however, in the fullest degree, the influence of heat, light, moisture, and the like, in the distribution of vegetable life, there still lies over and above them a primal arrangement, by which certain forms are naturally restricted to certain areas. This arrangement, which is seemingly not dependent on climate (for the plants thrive equally well when transferred to other areas), imparts a certain physiognomy to these regions; and thus botanists, entering more minutely into the geographical aspects of their science, subdivide the earth into *regions* and *provinces* according to their prevalent floras. Such subdivisions lie beyond

the limits of our outline, but the learner will readily perceive their bearings when he considers—*first*, that some forms, like the tea-plant and camellia, are peculiar to eastern Asia; some, like the eucalypti and casuarinæ, to Australia; others, like the magnolia, to the southern latitudes of North America, and so on: while, *second*, that every tribe of plants has a special aspect or physiognomy, and where such tribes prevail, that physiognomy will be imparted to the landscape. Wherever, therefore, certain orders are peculiar, and a certain number of genera and species prevail, this constitutes a botanical "region," such as the region of saxifrages and mosses, the region of magnolias, the region of camellias and teas, region of palms, and so on, making in all some twenty-four regions, into which the earth's surface has been botanically divided. In like manner with aspect or "physiognomy," as the Palm form, the Banana form, the Mimosa form, Cactus form, Heath form, Grassy form, Willow form, &c.—there being in all twenty-two such forms, which are readily distinguished even by the eye of the unbotanical observer.

269. In the same way it is not unusual to divide the Old and New World into *agricultural* zones, in something like the following order, from the tropics to the northern limit of profitable culture—1. Zone of rice and maize; 2. Maize and wheat; 3. Wheat, rye, buckwheat, pease, and beans; 4. Barley, oats, and potato. Commenting on the agricultural zones, Professor Balfour remarks, that in the Old World, "the *zone of barley, oats, and the potato*, includes Finmark and the higher districts of Scandinavia, the Faroe Islands, and the most northerly part of Scotland and Ireland—the north boundary being 62°, 70° and 67°, and the south boundary 57° in Scotland, 52° in Ireland, 65°, and 60°. That the *zone of rye and wheat* occupies the greater part of Europe north of the Alps, and extends to about 50° latitude, or as far as the polar limit of the cultivation of the vine; and that in this zone buckwheat, pease, and beans, are also important articles of food. That the *zone of wheat* includes those parts of Europe and western Asia which lie south of the 50th degree; and that in several districts maize is cultivated as well as wheat. The *zone of rice and wheat* embraces those provinces which are subject to the influence of tropical seasons—in tropical western Africa rice and maize being the chief grains. This zone extends from about 15° N. lat. to about 28° S. lat." In the New World Berghaus distinguishes the following zones:—1. Rye, wheat, and barley (summer cereals); 2. Rye and maize; 3. Wheat and maize. Wheat. In the tropical zone maize is the principal cereal crop.



becomes a subject not only of scientific interest, but of true economic importance.

272. The great question—How the globe has been clothed with its present vegetation ? is one that belongs more to the domain of botany than that of geography ; and yet on this point we cannot refrain from transcribing the very cautious and temperate views of the authority above quoted. "From all that has been said on this interesting subject," he remarks, "we are led to the conclusion that many plants must have originated primitively over the whole extent of their natural distribution ; that certain species have been confined to definite localities, and have not spread to any great distance from a common centre ; while others have been generally diffused, and appear to have been created at the same time in different and often far-distant localities ; that migration has taken place to a certain extent, under the agency of various natural causes ; that geological changes may, in some instances, have caused interruptions in the continuity of floras, and may have left isolated outposts in various parts of the globe ; and, finally, that social plants were probably created in masses, that being the natural arrangement suited to their habits."

otamus, and tapir; the crocodile, turtle, boa, and larger; the ostrich, flamingo, peacock, parrots, humming-birds, ially of birds remarkable for their brilliant and varie- umage. Insect life is also much more varied and exuber- ical than in colder latitudes—attaining its maximum y, in size, activity, and brilliancy of hue, within the luxu- ions of Brazil, Guinea, and the Indian Archipelago, and declining towards either temperate zone. This declen- not take place, of course, everywhere in the same ratio, ver there is abundance of plant-life, there certain insects n corresponding numbers; and variety in plant-life is led by a greater variety of insect-life—each genus, and species, being limited to its own peculiar vegetation. e Temperate zones, on the other hand, though marked armer limits by the presence of such tropical forms as ackal, hyena, crocodile, &c., are, on the whole, the head- such ruminants as the ox, bison, buffalo, goat, sheep, k. The useful animals—that is, those more especially mestication, like the horse, ox, sheep, dog, &c.—increase r zones, while the larger carnivora decrease not only ut in power and numbers. Peculiar to them also are camel, the wild boar, wolf, fox, and beaver; the the northern hemisphere and the kangaroo in the e eagle and falcon, turkey, goose, grouse, and pheas- irds; while reptiles become fewer and smaller the proach the arctic zone. Insects also, with the ex- etles, decrease in species, size, and brilliancy—the specifically more abundant in temperate than in , though inferior in size and brilliancy of colouring. rctic zone (for the Antarctic is almost exclusively e ocean) is characterised by greater uniformity in few species but by numerous individuals, and ie quiet and sombre colouring both of its birds s. The reindeer, musk-ox, brown bear, polar : fox, and sable, are peculiar to this region; the :quent its summer seas are chiefly migrants from e colder-temperate zone; and reptile life is :re it may be observed that as the land in ere lies in great contiguous or all but contigu the southern it consists of far-separated sp. ere is a greater similarity between the fauna a han of southern zones. The Life of the Antar- dissimilar and far-scattered specks and patches,

[The page contains several lines of text that are extremely faint and illegible due to heavy noise and corruption. The text appears to be a list or a series of entries, but the specific details cannot be discerned.]

gical kingdom, or Australia, which, besides the continent of Asia and Van Diemen's Land, comprises the islands to the west, including New Zealand, and the numerous groups of islands, and these, from the small extent of space to which they are confined, the uniformity of the soil, climate, and produce, and the great uniformity of the animal world, form only one province.

The *fourth* kingdom consists of Africa, the peninsula of Arabia, and the islands of Madagascar, Bourbon, and Mauritius. The *fifth* kingdom consists of North and South America, or the New World, and is divided into four provinces—*viz.*, those of arctic, temperate, tropical, and southern America. The arctic is divided into a northern province by a curved line, beginning about the North Pole and passing eastward through the North Pole.

The temperate province begins at the North Pole and extends south to the Tropic of Cancer. This line coincides with the 46° of latitude, and the province is chiefly composed of British North America. The northern province extends south to the Tropic of Cancer, whence it is bounded by a line drawn from the river Bravo del Norte to the northern extremity of California, and comprises the United States, Texas, and the northern part of Mexico. The tropical province extends from the Tropic of Cancer to the Tropic of Capricorn, or 40° south, where it is joined by the southern province, which comprises Patagonia and the islands south of Cape Horn.

The uniformity of the terrestrial fauna, so also in a great measure the uniformity of the marine, though at first sight there may seem no interruption of change and community of habitat. Variety of genera characterises the seas of the torrid zone; uniformity of species and immense numbers of individuals mark the fauna of the temperate zone. The fishes and shell-fish of the tropics are noted for their brilliant tints; those of the arctic regions are of sombre hues. The right whale never traverses the cold waters of the higher latitudes in either hemisphere, the sperm whale, on the other hand, is unknown beyond the limits of the Pacific. Unknown in the torrid zone, the sperm whale occurs in thousands in the colder-temperate zone.

The headquarters of the sharks lie within the temperate zone. The tunny rejoices in the genial waters of the tropics; the cod, haddock, pilchard, herring, and salmon are the food-fishes, in fine—attain perfection in the waters of the higher latitudes. The constituents of the marine life are nearly the same throughout, and yet the tropical fishes elaborate their structures within the tropics, while the fishes of the ocean.

279. As with the horizontal areas of the water, so in like manner with its various depths or bathymetrical zones. The *littoral zone* (par. 267) of our own seas, for example, is characterised, according as the bottom may be rocky, sandy, or muddy, by such shell-fish as the periwinkle, limpet, mussel, cockle, and razor-shell; the *laminarian* by star-fishes, the common sea-urchin, tubularia, modiola, and pullastra; the *coralline* by the disappearance of the ordinary shore shells, and the abundance of buccinum, fusus, trochus, venus, pecten, and the like; and the *coral zone* by forms of star-fish, cidaris, and brachiopod mollusca that cannot exist in shallower waters. As to the extreme depths of ocean, they are generally presumed to be, like the extreme elevations of the land, altogether barren and lifeless. It is true that some recent deep-sea soundings in the North Atlantic would seem to point to a different conclusion; but these, before final acceptance, require the confirmation of further and independent experiment.

280. It must ever be borne in mind, however, that, obvious as may be the influence of external conditions on the distribution of animal life, there is over and above them an aboriginal dispersion that science in its present position is unable to account for. Why, for instance, should the kangaroo and ornithorhynchus be restricted to Australia, the apteryx to New Zealand, the hippopotamus and giraffe to Africa, the camel to the Old World, and the llama to the New? Or why should the New World, notwithstanding its predominance in vegetation, be inferior in variety and intensity of animal life to the Old? But while these aboriginal differences exist and remain unaccounted for, the student should remember that distant regions, having nearly the same conditions, are peopled by what are termed *representative species*—that is, species not zoologically identical, but merely representing one another in the economy of nature, and fulfilling similar functions. Thus, the camel of the Old World is represented by the llama of the New; the lion and tiger of the Old World by the puma and jaguar of the New; the ostrich of Africa by the rhea of South America and the emu of Australia; and the crocodile of the Nile by the gaviol of the Ganges and the alligator of the Amazon. It should also be borne in mind that local conditions of food, shelter, healthful position, freedom from enemies, and the like, are also operating causes in the distribution and dispersion of animal life; and that where these are wanting, whole families will shift ground, or altogether disappear, even when the great conditions of temperature remain unchanged.

281. As in the vegetable world, so also (though to a less extent) in the animal, certain species have a greater elasticity of

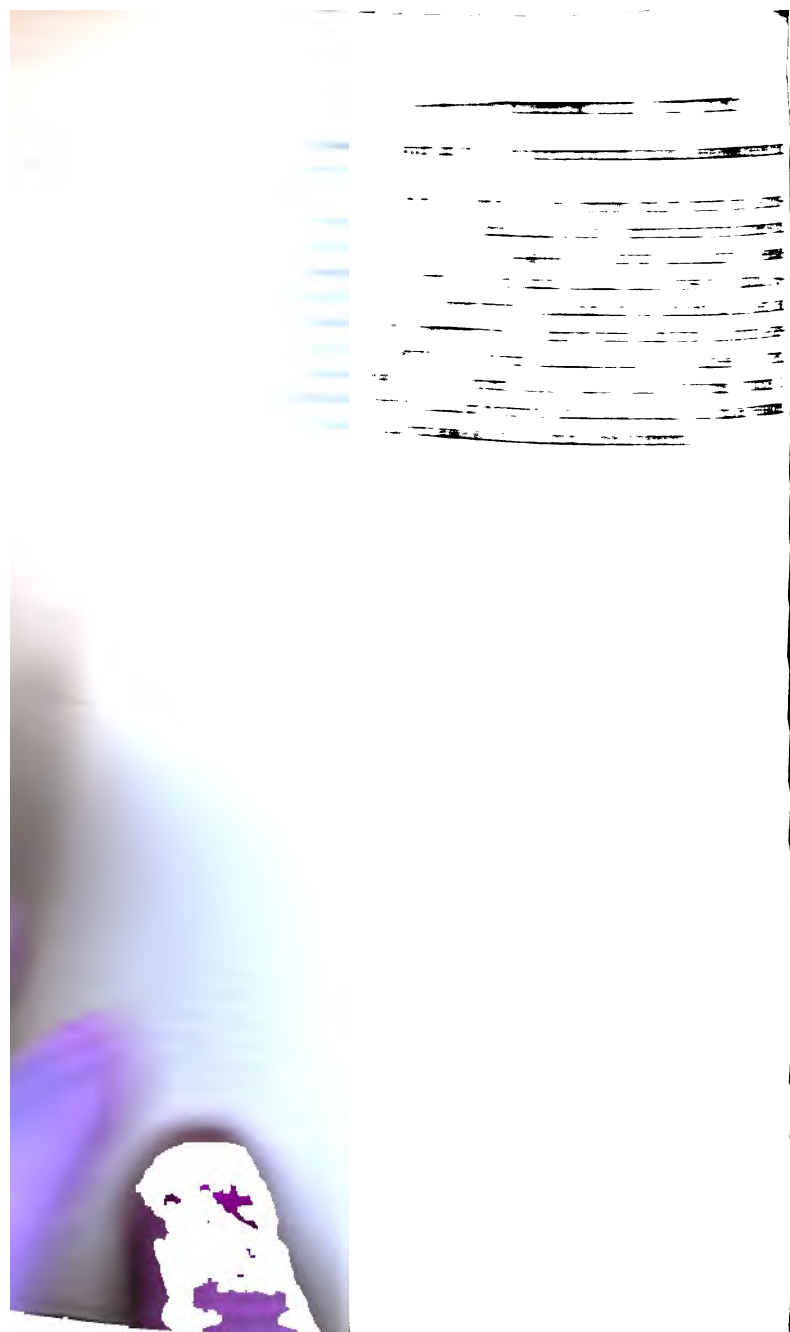
constitution, which enables them to subsist under a greater variety of conditions, and naturally, therefore, to enjoy a wider geographical range. Operating upon this principle, and a knowledge of climatology, man has been enabled to transfer from one region to another a considerable number of animals, either for the purposes of his convenience or luxury. All the domestic animals—horse, ass, ox, sheep, goat, pig, dog, cat, barn-fowl, &c.; many birds, prized for their beauty or song; and rats, mice, insects, and other creatures, considered as “pests and vermin,” have accompanied him over the habitable globe. His efforts in this respect—extirpating, transferring, and acclimatising—have been incessant; and thus creatures naturally of widely distant habitats have been, and are still being, brought together into one common area. In this way the domestic animals of the Old World have been transferred to the New, where they were unknown at the time of its discovery by Columbus; some of the New World fauna transferred to the Old; and not only the domestic animals, but the birds, fish, and even shell-fish of Europe, transported to Australasia, where, within little more than a century, their genera were totally unrepresented. But as in the vegetable world, so in the animal, there is a limit to this system of transference, and man best studies his own interest and the comfort of the lower animals by fostering them mainly within their own native habitats, and sharing in their larger produce through the more profitable method of commerce and exchange.

Interdependence of Plants and Animals.

282. As plants and animals are alike dependent on external conditions, so both are, to a certain extent, dependent on one another. Both, for example, are dependent on the atmosphere, yet the oxygen which the plant exhales is inhaled by the animal, and the carbonic acid exhaled by the animal is absorbed and assimilated by the plant. The plant, rooted in the soil and casting abroad its leaves and branches in the atmosphere, though seemingly deriving the main elements of its growth from inorganic sources, is nevertheless stimulated into life and exuberance of organic decay, and many of the lower fungi are found only where such decomposing matter is abundant. Herbivorous animals, as is well known, subsist directly on plants, while the carnivorous prey upon the plant-feeders, thus also ultimately dependent on the vegetable world for their subsistence. Wherever vegetable life is varied and

waters. Leaving the nature and origin of Life to the biologist, it has been shown that plants and animals are dependent for their continuance on the external conditions by which they are surrounded, and that any change in these conditions would materially affect, if not destroy, their existence. For this reason, plants and animals have a definite distribution over the globe; heat, light, and moisture being the great regulators of the one; climate and food the governing conditions of the other. In this way vital variety and exuberance culminate within the tropics and decline as we proceed towards either pole—declining also in an analogous manner as we ascend from the level of the sea into the higher elevations of mountains. Each zone or belt of the earth has thus its own special flora and fauna—that is, is characterised by genera and species not naturally occurring in other regions. As marked variations occur within narrower limits than the torrid, temperate, and frigid zones, botanists subdivide the earth's surface into equatorial, tropical, sub-tropical, warmer-temperate, colder-temperate, sub-arctic, arctic, and polar belts; and these, as might be expected, correspond with lines of temperature rather than with parallels of latitude. As in the land, so also in the waters, each zone of depth, from the shore seaward, has its characteristic forms—littoral, laminarian, coralline, and coral; the extreme abysses of ocean, like the extreme altitudes of land, being apparently barren and lifeless.

Beyond these main horizontal and vertical arrangements of life, there is also an aboriginal dispersion of certain races over certain areas which science cannot account for; hence the subdivision of the earth's surface into botanical and zoological "regions" and "provinces," each subdivision being characterised by its own typical forms. These provinces form the special study of the botanist and zoologist; and the question how far the plants and animals of one region can be profitably transferred to another, becomes one of prime economical importance. Understanding the geographical conditions under which plants and animals naturally occur, and knowing, moreover, the intimate dependence between the vegetable and animal kingdoms, man, in his own migrations over the globe, will be better able to determine what to cultivate and what to extirpate, what to attempt acclimatising and what to continue in their own native habitats. Understanding, moreover, the relations that subsist between fauna and flora, he will, as a geographer, be better enabled to draw that intelligible picture of external aspects which it is the grand province of his science to depict; and from a knowledge of these aspects be further enabled to indicate to the merchant and trader the



XV.

ETHNOLOGY—RACES AND VARIETIES OF MAN.

Man as affected by External Conditions.

284. MAN, in whatever stage of civilisation he may appear, is always less or more influenced by the geographical conditions of the region he occupies. Unlike the lower animals, which either simply flourish under or succumb to these conditions, Man may struggle against and so far modify them; but still, to a great extent, his thoughts and actions, his industrial pursuits, his social polity, and religious beliefs, are all affected by the physical circumstances of his position. To argue otherwise were to ignore the principles of science, and lose sight of those zoological relations that subsist not only between man and the other animals, but between him and those external conditions upon which the continuation of his existence is so absolutely dependent. In savage life this influence is direct and perceptible; hence the difference between the semi-aquatic Esquimaux and the hunting Red Indian, though inhabiting the same continent; between the stationary vegetable-feeding islanders of the sunny Pacific, and the wandering omnivorous tribes of the scrubby plains of Australia; between the lithe and nerveless red man of the New World, and the robust and vigorous negro of the Old. Even where civilisation has made some progress, it is these conditions that still mainly determine man's habits and pursuits—rendering the inhabitants of the grassy steppe nomades and herdsmen, the indwellers of the river-plain tillers of the ground and growers of grain, and the men of the sea-coast traders and adventurers. And higher still, where populations have been long settled and civilisation has assumed its most advanced aspects, climate, scenery, natural products, facilities for intercommunication and exchange, are ever exercising their influence—rendering one nation wealthy and independent, another bold and enterprising, and a third, it may be, isolated and

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and the "charming variety" of another; of the "awe-inspiring gloom" of the forest, and the "cheerful hues" of the open landscape. Indeed it is to the influence of situation that we are in a great measure to look for national peculiarities—these peculiarities diminishing the more that nations extend their range of intercommunication, and the less they are restricted to their own narrow boundaries.

Characteristics and Distribution of Race.

287. Whatever the influence of external conditions in modifying the characteristics of race, we find Man distributed at present over almost every region of the globe—wandering in savage freedom under the tropics, flourishing in busy communities within the temperate zones, and struggling in diminished numbers against the inclemencies of the polar regions. Within the tropics he is chiefly a vegetable feeder; in the temperate zones he adopts a mixed vegetable and animal diet; while within the polar circle his diet is exclusively animal. But while in this respect he obeys, like plants and animals, the zonal arrangements of the world, unlike them the varieties of his race are distributed according to no law of latitudinal dispersion. As in districts of the same country we find differences of stature, physiognomy, dialect, and habits; so in the various countries of the same continent we find still wider differences in bodily appearance, mental constitution, language, and manners. Notwithstanding these well-known distinctions, there is among the inhabitants of certain regions a certain sameness in physical aspect, in colour of skin, in form of head and face, and also in mental disposition, that stamps them as distinct from the inhabitants of other regions; hence arises the idea of *varieties* or *races* of the human species. That these varieties or sub-species (for the difference seems greater in some instances than what zoologists consider a variety) have existence in nature, we have only to look at the condition of mankind, as at present scattered over the surface of the globe. Here, active, intelligent, and progressive; there, sluggish, dull, and stationary: here, enjoying the highest amenities of civilisation; there, grovelling in a condition little elevated above the brutes by which they are surrounded. And not merely do they differ in intellectual qualities, but in physical organisation, in mien and stature, in form of head and expression of face, in colour of skin, in strength and endurance, and, in fine, in all those purely bodily qualities by which one species of animal is distinguished from another.





1, Caucasian; 2, Mongolian; 3, Ethiopian; 4, Malay; 5, American.

that stretches between the Caspian and Black Sea, because tradition points to that region as the place of its origin; and it is also known by the term *Indo-European*, from its spreading over India and Europe from the Ganges to the farther shores of Iceland. The more important branches are the Hindoo, Persian, Arab, Circassian, Slavonic, Teutonic, and Celtic, with their various mixtures and alliances, which now constitute the nationalities of southern Asia and Europe. Of course, thousands of years have passed away in the development of these respective branches—each branch springing out from its predecessor, and assuming new features in body, mind, language, and beliefs according to the nature of their new region, though still retaining enough of the original stock to mark their origin and descent.

290. The distinguishing characteristics of these Indo-Europeans are—a light-coloured skin, varying from fair to tawny or swarthy; red cheeks; copious, soft, flowing hair, generally curled or waving; ample beard; small, oval, and straight face, with features distinct; expanded forehead; large and elevated cranium; narrow nose; and small mouth. In stature the Caucasian is taller than any of the other varieties; of erect gait; with rounded, well-proportioned limbs; moderately small extremities; and light, elastic step. The *White* race (for by this designation it is generally distinguished) has given birth to the most civilised nations of ancient and modern times; and has hitherto exhibited the intellectual and moral powers of human nature in their highest degree. Wherever the white man has established himself, the other races disappear before him. His proper field of development, however, seems to be the temperate zones in either hemisphere, for beyond them he degenerates physically and intellectually, and loses the higher characteristics of his race. And even as regards the whole species, it is held by some that "Man presents to our view his purest, his most perfect type at the very centre of the temperate continents—at the centre of Asia-Europe, in the regions of Iran, of Armenia, and the Caucasus; and, departing from this geographical centre in the three grand directions of the lands, the types gradually lose the beauty of their forms in proportion to their distance, even to the extreme points of the southern continents, where we find the most deformed and degenerate races, and the lowest in the scale of humanity."

291. The *Mongolian* variety is spread, as the name implies, over the central and northern regions of Asia, China, Japan, Burmah, Siam, and Cochin-China; and includes, moreover, the scattered inhabitants of the Arctic seaboard, both in the Old and New World continents. It embraces the Mongols, Turks, Tibetans,

inese, Indo-Chinese, Japanese, Kamtchatdales, Tungusians, riaks, and Samoiedes, in Asia ; the Turks, Finns, and Lapps, Europe ; and the Esquimaux of the North American arctic rens. In the Mongolian the skin is olive-yellow ; the hair thin, ree, and straight ; little or no beard ; head or cranium somewhat square-shaped ; forehead rather low ; face broad and flat-ed, with confluent features ; high cheek-bones ; eyes rather k, and obliquely directed towards the nose ; wide and small e ; and thick lips. In stature the Mongolian is below the lo-European ; but in the true Tartar, Turk, and Chinese, the ne is broad, square-set, and robust, with high shoulders, and rt and strong neck.

92. In intellectual and moral capacity the various branches of race differ very widely ; but on the whole they are inferior, energetic, and more stationary in their civilisation than the casian variety. "With the Mongol," it has been remarked, e melancholic temperament seems to prevail ; the intellect, lerate in range, exercises itself upon the details, but never s to the general ideas or high speculations of science and phil- hy. Ingenious, inventive, full of sagacity for the useful arts conveniencies of life, it nevertheless is incompetent to gene- e their applications. Wholly turned to the things of earth, world of ideas—the spiritual world—seems closed against him. whole philosophy and religion are reduced to a code of social als limited to the expression of those principles of human con- ice without the observance of which society is impossible." ally and morally, the highest attainments of the race appear e Chinese and Japanese, the Turks and Magyars having been ng amalgamated with Europeans as to assume a Western r than an Oriental phase of civilisation.

3. Under the *American* variety, ethnologists comprise all aboriginal races which peopled the New World prior to its very by Columbus in 1492. These are the Chippewyans, c, Pawnees, Cherokees, and other tribes in North America ; the Caribs, Solimoes, Guaranis, Araucanians, Patagonians Fuegians in South America. In this race the skin is or copper-coloured (hence the familiar designation (n) ; the hair is black, coarse, and lank ; beard scanty what similar to the Mongolian, but narrower, and e ; forehead low and retreating ; cheek-bones prominent rounded than those of the Mongol ; eyes sunk, and raised at their outer angle ; nose and other features r- inent. In stature the North American Indian is rather t and lithe in body ; and as a hunter, acute in his senses, a

remarkable for his endurance of fatigue and insensibility to pain. In South America the race greatly degenerates ; the Guaranis, the Fuegians, and other tribes being amongst the most degraded of savages, their wretched appearance being in many instances aggravated by artificial distortion of the head and facial features.

294. In intellectual and moral qualities the American Indians resemble in many respects the Mongolians. Like the Mongols, they have remained stationary, but at a much lower point of civilisation, if we except the ancient occupants of Mexico and Peru, whose geographical position seems to have imparted to them a greater degree of energy and activity. In North America the race is rapidly disappearing before the white settlers ; in South America, less fitted for the White, the inferior and more sparsely scattered tribes have been little interfered with. "The indigenous man of America," says M. Guyot, "bears in his whole character the ineffaceable stamp of the peculiarly *vegetative character* of his country. Living continually in the shadow of those virgin forests which overspread the earth that he inhabits, his whole nature has been modified thereby. The very copper hue of his complexion indicates that he lives not, like the negro, beneath the scorching sunbeams. His lymphatic temperament betrays the preponderance in his nature of the vegetative element. The Indian is of a melancholy, cold, and insensible race. Foreign to our hopes, our joys, our griefs, it is rarely that a tear moistens his cheek, or a smile lights up his eye. The most barbarous tortures cannot extort from him a single complaint, and his stoical indifference is disturbed only by vengeance or jealousy. If he sometimes exhibits a display of prodigious muscular force, he is yet without endurance. . . . The social condition of the Indian tribes is hindered, in an equal degree, by the powerful influence of his vegetative character. The Indian has continued the man of the forest. He has seldom elevated himself above the condition of the hunter, the lowest grade in the scale of civilisation. The exuberance of the soil has never been of value to him, for he asks not of the earth his nourishment. He has never even ascended to the rank of the pastoral man. With him no domestic animals are maintained to feed him with their milk, or clothe him with their fleeces, as they are by the nomadic races of the Old World. From one to the other extremity of America we find the same lamentable spectacle ; the people of the elevated table-lands of Mexico and Peru are the only exceptions to this picture, and this exception goes far to establish the influence of the vegetative and humid nature of the lower plains of America."

295. The *Ethiopian* race, in one or other of its branches, in-

habits the whole of Africa, with the exception of Egypt, Abyssinia, Tunis, Tripoli, and Morocco on the north, and Cape Colony on the south. It embraces Hottentots, Bushmen, Kaffirs, Negroes, Gallas, Tibboos, Mandingoes, and other tribes, differing widely among themselves in physical and mental aptitude, but all, from time immemorial, remaining in a barbarous or but very partially civilised state. In this variety, which derives its name from the Ethiopia of the ancients, the skin is black (hence the familiar designation, Negro—Lat. *niger*, black); the hair short, black, and woolly; skull compressed on the sides, and elongated towards the front; forehead low, narrow, and slanting; cheekbones very prominent; nose broad and flat; jaws projecting so as to make the upper front teeth oblique; lips, especially the upper one, very thick. In stature there are great differences among the different branches of the race—some, like the Kaffir, being of average size and fairly formed; others, like the true negro, also of average size, but ungainly in form and limb, with large, flat feet and hands, and shuffling, awkward gait; and some, again, like the Hottentot and Bushmen, of stunted stature, and with slender, ill-formed limbs. Intellectually, the Black race has ever remained in a rude and barbarous state; hence the subjection of one branch to another branch among themselves; and hence, also, their enslavement, from time immemorial, by the white variety. This is not the place to enter upon the question, how far the negro is capable of attaining the higher phases of civilisation; but the fact remains, that neither of himself, nor in any of his admixtures with other races, has he shown much aptitude for intellectual or social advancement. Even in the fine genial clime of the highlands of equatorial Africa, as described by Captain Speke, the negro remains much the same—easy, indolent, sensual, enslaving or enslaved, but never rising to the higher conceptions of social or moral polity, and still less to the attainments of science or philosophy.

296. The *Malay* race (so called from the Malayan peninsula) includes the widely-scattered and chiefly insular inhabitants of Malaysia, Australasia, and Polynesia. The population of these widely-spread districts differ, as might be expected, very widely from each other—those of Malaysia and Polynesia being of a brown or lighter colour, and somewhat resembling the Mongolians; while those of New Guinea and Australia (the Papuan negroes, as they are termed) are of a dark colour, and more closely approximated to the negro type. Intellectually, also, there is a similar difference, there being little in common between the Malay of the Indian Archipelago and the savage inhabitant of New

similarity between the smallest and most remote parts of Australia and the burning, hot, and never unhumane of New Zealand; or between the calculating nature of the New Zealanders who live under a temperate climate, and the mild, simple, and careless character of the true aboriginal of the sunny Pacific. Taken, however, as described by travellers, the skin of the Malay varies from a gold tawny to a deep-brown; hair black, crisp, and somewhat inclined to curl in the true Malay, and tufted and frizzled in the Papuan; head rather narrow; bones of the face large and prominent; nose full and broad towards the lips. In civilisation the Malay race has hitherto made little advancement. In the Indian Archipelago it has, like the Mongolian, long remained stationary; in Polynesia, some progress appears under tutelage of the white, though the areas are apparently too small and too widely separated ever to be of much importance; in New Zealand it seems reluctant to amalgamate with the new settlers; while in Australia it is rapidly dying out before the encroachment of the European immigrant.

207. Taking these varieties as aids to the general arrangement and consideration of mankind, it must be remembered that there are not only admixtures among conterminous races (Caucasian and Mongol, Mongol and Malay, Mongol and American), but admixtures also between immigrant and native races (Brazilians, Peruvians, Mexicans, &c.), which render sharp lines of demarcation impossible, and unnecessary as impossible. The consideration of

especially to Ethnography and Philology, of colour, types of skull, facial features, and into account, but dialects of language, and forms of government, are all considerations, affinities, and history of the races lie beyond the scope of our physical geography may consider as varieties above enumerated, Caucasian, Mongolian, and is a sub-variety of the Mongolian of the Mongol and partly is merely that our science of language, and the progress of ethnology, and Philology, and special treatment and elucidation, it must be confessed that many and unsatisfactory, and must be considered more in a Natural History, and apart from the other relations,

physical and vital, of the universe. Anthropology, or the natural history of man, treated as the natural history of any other animated being, is a study that has scarcely yet received a name and place among the other branches of human knowledge.

Conditions of Civilisation and Progress.

298. Such is the usual subdivision of mankind into varieties or races, and such the existing distribution of these races over the surface of the globe. The subdivisions may to some extent be arbitrary; but as there are actual differences of colour, form of head, facial expression, and the like, and as these physical features are accompanied by strongly-marked differences in mental constitution, in form and structure of language, and in intellectual capability, the distinctions in the main must be founded on nature.

As to the prehistoric distribution of man, neither archæology nor geology, in the absence of reliable remains, can arrive at any certain conclusion. Within historical time, however, the various races, while peopling most densely the regions they now occupy, have ever been less or more encroaching on each other's domain—the inferior giving way to the superior and more civilised. The Ethiopian, in its numerous tribes and branches, has remained stationary in Africa. The Malay, chiefly an insular race, has spread itself, in one or other of its branches, over the islands of Southern Asia and the Pacific. The Mongolian, while claiming Central and Eastern Asia as its headquarters, has spread partially into Europe, along the entire seaboard of the Arctic Ocean. The American Indian, on the other hand, has partly repelled the Mongolian after its spreading wave after wave over Western Asia, North Africa, and the whole of Europe, has within the last three centuries taken possession of the greater portion of North America, Mexico, California, &c.); of part of South America, Brazil, Peru, &c.); of South Africa; of New Zealand; while his influence is felt in every region of the globe.

As to the future of the human race, the question of subsistence can be obtained, the question of increase in numbers—his in the question of facility or difficulty of obtaining more than his own wants rest much on his knowledge of natural laws, on the words, on the natural capabilities of the products not possessed by other races, the products form subjects of barter.

and exchange, and thus he acquires wealth and the power to command luxuries. Raised above the mere physical struggle for existence, the higher faculties of his mind—imagination, invention, reflection, moral perception, and religious sentiment—begin to develop themselves, and man passes from the domain of savagery into the categories of civilisation. To trace the course of civilisation lies beyond the scope of our subject; but it is evident, from what has been repeatedly stated, that its advancement (laying altogether aside the consideration of Race) depends, in a great measure, on the geographical or physical conditions by which it is surrounded. Wherever there exists a favourable climate, the means of subsistence, and opportunities of interchange and barter—in other words, wherever there are the objects and means of successful industry—there civilisation will manifest itself; and just as equitable laws, protection of property, freedom of action, and liberty of opinion are enjoyed, so civilisation will advance in a corresponding ratio. In absence of these adjuncts it has passed, and may yet pass, from nation to nation; but in the aggregate its maintenance from epoch to epoch has been secure—its progress seems illimitable.

300. It may be noted, however, that, other things being equal, a maritime or oceanic population will more readily excel in civilisation than a continental or inland one—their progress being directly as their means of interchange and intercommunication with other countries. Again, a population like that of China, enjoying vast and equable geographical conditions, will remain more stationary than another even of the same race (as the Japanese) who possess more limited but more varied surroundings. Further, populations cut off from intercommunication by land-barriers, such as vast deserts and mountain-chains, remain more isolated and less progressive than others separated by the widest oceans; hence the sharp definings of certain Asiatic races, such as those of China, India, Tartary, and Arabia. Still further, variety of external conditions and variety of natural products necessarily produce greater contrasts, greater activity, and greater intelligence; hence the varied and superior civilisation of a diversified continent like Europe compared with the other great sections of the globe. In fine, the effect of geographical condition and consequent industry is too often lost sight of in our social and political reasonings; and it may be laid down as an axiom, that no great continent possessing different climates, different products, and necessarily different pursuits, can possibly be governed by the same laws, or permanently united under the same forms of government.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been briefly directed to the varieties and distribution of the human species—Ethnology or Ethnography being the science which treats of these distinctions. It has been shown that Man, though possessing a greater elasticity of constitution than most of the lower animals, and capable of enduring under almost every climate, is still, to a great extent, influenced by the external conditions by which he is surrounded, both in his physical and mental relations. Whether owing to these influences, or arising from aboriginal differences which science cannot explain, Man now appears in several *varieties* or *races*—each occupying well-marked territories on the globe, and distinguished by peculiarities of colour, form of head, facial expression, and other *physical* features, as well as by equally obvious *intellectual* and *social* qualities. These varieties are the *Caucasian* or *white*, the *Mongolian* or *yellow*, the *American* or *red*, the *Ethiopian* or *black*, and the *Malay* or *brown*—each embracing a great number of tribes, branches, and nationalities, differing in language, social polity, and other peculiarities.

The Caucasians, or Indo-Europeans, inhabit the south-western section of Asia, the northern belt of Africa, and nearly the whole of Europe, and have, in modern times, extended their dominion to large areas of North and South America, South Africa, South Australia, and New Zealand. The Mongolians, concentrated chiefly in Central and Eastern Asia, have partially penetrated into Eastern Europe, but are most extensively spread in scattered communities along the entire seaboard of the Arctic Ocean. The Malays, having their headquarters in Malaya and the Indian Archipelago, are spread, in one or other of their tribes, over Australia, as well as over all the island groups that stud the bosom of the Pacific. The Ethiopians, through drafted hither and thither as the slaves of the white man, have been mainly stationary in Africa, the natural home and habitat of their race; while the Americans, or Red Indians, have been equally restricted to the New World continent. As a whole, the negro and Red Indian have made, and still make, the least progress in civilisation; hence their easier subjection by the higher races, and hence also their rapid disappearance before them. The Malay and Mongolian come next in order; and though some of their sections (Chinese, Japanese, &c.) have arrived at considerable eminence in the industrial arts, yet in both races the essentials of higher progress

seem wanting, and hence their torpid and stationary aspect. By the white race alone do we find displayed the higher efforts of bodily and mental activity—hence in ancient times the civilisations of India, Assyria, Palestine, Egypt, Phœnicia, Greece, and Rome; and in modern times those of Western Europe—Austria, Germany, France, and Britain; of the United States and Canada; and, generally, of our colonies, in whatever region of the globe they may happen to be established.

The conditions favourable to this civilisation are partly of a geographical or physical nature, and partly intellectual; and wherever the two are in fortunate conjunction, there the progress of the white race is certain, and illimitable as certain. We say of the *white* race, for as yet neither of the other varieties have at all approached the standard of his civilisation in temperate zones. Indeed it may be fairly questioned, on psychological grounds, whether they are naturally capable of the same kind and degree of social, moral, and intellectual attainments; and also whether, in all the temperate and sub-tropical regions at least, they are not in time destined to disappear before the spread and progress of the white, or to be imperceptibly absorbed into his superior numbers and advancement. Under the equatorial zone—and be it observed that only a very small portion of the land-surface is strictly equatorial, and even of that portion a considerable share, like the highlands of equatorial Africa, Mexico, and Colombia, are capable of being inhabited by the white man—the black and brown races, in some of their offshoots, may rise to a subordinate civilisation; but everything we know of the past points to illimitable progress in the white, and to a limit and declension in the other varieties of our species.

The student desirous of entering more minutely into the study of Ethnology and its kindred branches, may consult such works as those of Dr Prichard, Dr Latham, Messrs Gliddon and Nott, Mr Brace, and others, along with the plates and letterpress in the 'Physical Atlas' of A. K. Johnston.

XVI.

GENERAL REVIEW, APPLICATIONS, AND DEDUCTIONS.

Objects and Principles.

301. THE object of Physical Geography being not only to describe the external aspects of the world, but to determine the causes by which these aspects have been, or are still in course of being, produced, it has been necessary, in the preceding chapter, to deal with principles as well as details. Indeed, the aim throughout has been to present our planet as subjected to general laws, believing that, when these are understood, there will be little difficulty in comprehending their modifications in local and limited areas. Let the student clearly understand the origin, for example, of winds and rains, of tides and currents, and he will soon find his way to determine the causes that produce their modification in any special locality. Let him once comprehend the main causes of climatic diversity, and the manner in which it affects the distribution of plants and animals, and he will have no difficulty in accounting for the peculiar climates of individual countries, or for the plant-life or animal-life by which they are peopled. The great object in an outline like the present is to inculcate principles; the details of geography would require volumes for their enumeration.

302. In accordance with these views, attention has been directed to the planetary relations of the earth—its figure, motions, dimensions, &c.—as on these depend its light and heat, its alternations of day and night, summer and winter, and, in general terms, all that gives rise to change and diversity in its external conditions. It is, in fact, to its solar relations that the earth owes, if we may so speak, its life and activity, deriving therefrom *directly* its rotation, revolution, heat, light, seasonal differences, and tides; and *indirectly* its winds, waves, and currents, its rains, snows, and frosts—all that produces diversity in the distribution of its plants

and animals, and change in the geological relations of its rocky exterior. It was necessary, also, to consider the individual structure and composition of the globe, and the geological changes which, under the operation of aqueous, igneous, and meteoric forces, that structure has been and is still undergoing. On these forces depend the distribution of sea and land, the formation of highland and lowland, the production of soils, and all those exterior aspects which influence so decidedly the character and localities of the plants and animals by which it is peopled.

303. Seizing upon the present terraqueous aspects of the globe, and regarding its geological changes as only appreciable at long and distant intervals, the more immediate province of our science was to investigate the relative distribution of its lands and waters, the disposition, highlands and lowlands of the one, and the configuration, depth, waves, tides, and currents of the other. Understanding the relations of land and water, and their necessary actions and reactions on each other, attention was next directed to the atmosphere by which both are surrounded, through which the light and heat of the sun are diffused to both, by which the plant-life and animal-life of both are sustained, and in which are elaborated the winds, rains, frosts, snows, and other phenomena that constitute the essentials of weather and climate. This all-encircling atmosphere is the great bond of union between land and water, between plants and animals, equalising and regulating the heat and moisture of the former, and conveying and supplying the vital gases so indispensable to the life and growth of the latter.

304. The consideration of this earth revolving through space as part of the solar system, composed superficially of land and water, surrounded by an atmosphere, and receiving heat, light, and other influences from the great central orb, constitute what may be termed the *physical* or *inorganic aspects* of geography. On the other hand, the study of the earth as peopled by plants and animals, and inhabited by man, capable of applying the whole to his own social and moral advantage, form its *vital* or *organic features*. In other words, the one relates to the *Physics* of the earth, and includes considerations merely of a mechanical and chemical nature; the other to its *Life*, and involves the more intricate problems of physiology and psychology. The study of the vital world, the distribution of its plants and animals, the causes concerned in that arrangement, and the dependence of the one kingdom on the other, becomes, therefore, one of the most attractive themes in geography. Still higher, however, and of more immediate interest, is that which deals with our own ~~race~~—their physical and mental peculiarities, their dispersion over the globe, and

question how far geographical conditions and the pursuits at thereon may influence their social, mental, and moral progress.

But our science has its practical as well as theoretical importance, its economic as well as its scientific aspects. A knowledge of the distribution of sea and land—the winds, tides, and currents of the one, the highlands, lowlands, and climate of the other, and the mineral, vegetable, and animal products of both—indispensable to successful navigation, commerce, and agriculture.

The duty of determining the earth's mineral, vegetable, and animal products, and how far they can be rendered available for the purposes of everyday life, is not less imperative than the solution of its physical and vital problems. It is of vast importance to be acquainted with the character, abundance, and accessibility of nature's products, but it is not less important to learn how to apply them. All knowledge of nature is good of itself, and its value is doubly enhanced when it is made to minister to our common humanity. Combining, therefore, its theoretical with its practical bearings, and remembering that every country is characterised by its own natural products, and has consequently something that no other country can supply, Physical Geography is paramount claims alike on the attention of the philosopher, the statesman, the sailor, the farmer, the merchant, and manufacturer.

306. The material wealth of the globe—that is, the products derivable from the mineral, vegetable, and animal kingdoms, and capable of being employed so as to administer to the comforts and luxuries of life—forms the leading theme of economic geography. Every country, in virtue of its geological age and formation, has some special mineral or metal in greater or less abundance; and every region, in virtue of its position and climate, produces vegetables or animals peculiar to its own area. Man's ingenuity is ever on the rack for new inventions in the arts and manufactures; and as all his raw materials are drawn from one or other of the realms of nature, he turns to Physical Geography for indications of the character, abundance, and accessibility of products that belong to the different countries of the globe. Commerce produces commerce, commerce brings about contact between the most widely diverse and separated regions, communion is the main incentive to civilisation and human progress. In this way Britain draws the raw materials of her manufactures from every accessible portion of the globe, re-exports thither her manufactured goods, and thereby creating new new activities, new ideas, and all, in fine, that arises from

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comprehend why the rocks (the old sea-sediments) should differ from those of another, why the one should differ from those of the other, could be low and alluvial while another is a feature being the product of a certain time in earth's relations. In this way, too, we can see the formation of deltas, of sand-dunes along the mid-ocean, of the shoaling of certain seas, changes of plant-life and animal-life incident to changes of habitat. History records the uprise of the depression of others, the appearance of the outbursts of new volcanoes, the increasing forms of life or their entire extirpation, the destruction of forest-growths and the succession of others, the extinction of certain aboriginal races of men and the rise of others over the same areas—changes which appear inexplicable but for this law of incessant mutability. It is also by bearing in mind this great feature of change that we can account for the similarities that exist between the flora and fauna of different continents that may at one time have been continuously united, though now widely separated by expanses of water. The plants and animals of Britain, for example, claim affinity with those of Europe, and this through land-connections that existed long before their separation by the Strait of Dover. By carrying this idea of mutation into all our reasoning, physical geography becomes a more intelligible part of history—connecting the past with the present, and preparing the philosophic mind for the nature of the changes that must be the inevitably approaching future.

As formerly stated (Chap. III.), the chief agents concerned in the modification of the earth are the winds, rains, frosts, and the action of the atmosphere, which are ever loosening and abrading the exposed rocky surface; the streams, rivers, tides, and ocean-currents, which are incessantly wearing away and re-depositing the eroded materials along the shores of the sea; and the earthquake and volcano, whose operation is like incessant upheaving and depressing the crust of the sea-bed into dry land, and now submerging it beneath the waters. No doubt, the consideration of these agencies belongs more especially to geology; but their result is directly on the arrangement and moulding of the terrestrial surface, that they cannot possibly be overlooked by the geographical observer, either in his descriptions or in his determination

good in their applications to special in-
 of analysis of the respective continents
 al reader as well as to the student, and
 es but slenderly understood may find
 sion by its application to particular
 under the notice of the local observer.

Europe, Asia, Africa, North America,
 a—each presenting features and pheno-
 ut all readily intelligible and in perfect
 principles laid down in the preceding

Continental Aspects—Europe.

principles laid down in the preceding chap-
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 and the 10th degree of W. and 64th of
 bounding line is rendered so irregular by
 and gulfs, and the projection of peninsulas
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 of the Atlas. Its area, as already stated, is
 square miles, of which about 317,500 be-
 and islets. Within this area there is every
 any limits) of surface; and it is this diver-
 Europe its especial character as compared
 continents. Devoid of immense plains like
 is not marked by the same uniformity of
 al life that characterises the New World; and
 vast deserts and plateaux that occupy so much
 it is not marked by those strong contrasts
 that belong so peculiarly to the greater portion
 everywhere with diversity of surface there is the
 connection, and thus it possesses a compactness
 variety, if we may so phrase it—that is not
 the other continental land-masses.

Understanding this unity of conditions, it must
 t the mountain-systems of Europe (Chap. VI.)
 south, confer on its southern section an irr-
 ect; while the northern section, from the German
 ough the Netherlands, Prussia, and Russia, is gener-
 little interrupted by elevations or depressions.

have thus a southern region characterised by its mountains, tablelands, and intervening valleys; and a northern (Chap. VII) marked by a predominance of pasture-plains, heathy wastes, lakes, and morasses. Unless in the extreme north, the greater proportion of the surface is more or less improved and under cultivation; and though large tracts are still occupied by natural forest, heath, sandy waste, lake, and morass, yet, on the whole, the natural aspect of Europe has been much more modified by man than that of any other continent. In other words, the natural conditions of its soil and climate have been more interfered with by man's operations than those of any other region, and in a corresponding degree, also, the plants and animals by which it was originally peopled. It is the great headquarters of civilisation, commerce, and cultivation; and thus, in all our reasonings on its geographical conditions, the modifying influence of man must be taken into account as an important and pervading element.

314. Geologically, Europe presents illustrations of every system, from the crystalline schists to the most recent alluvia, and from the deepest-seated granites to the latest volcanic eruptions (see Map in Atlas). From the broken and undulating nature of the country, these formations are repeatedly brought to the surface in all the northern and western districts—northern and eastern Russia being the only region where formations are continuous over extensive areas. In this way the mineral and metallic treasures of Europe become more readily available; and these consist, in general terms, of granites, porphyries, marbles, limestones, gypsum, rock-salt, sulphur, sandstones, fire-clays, pottery-clays, alum-shales, sands, flints, and other mineral substances used in the arts and manufactures; of iron, copper, tin, lead, silver, mercury, manganese, zinc, antimony, and other metallic ores; of gold and platinum, though less profusely than in some other regions; and of most of the precious or ornamental stones, with the exception of the diamond, Oriental ruby, and some varieties of the sapphire. This abundance and availability of the useful minerals and metals enabled her inhabitants to engage at an early period in arts, manufactures, and commerce; and it is to this same abundance and availability that her present superiority in mechanical, manufacturing, and commercial industry is mainly attributable. From the absence of great rivers, and the paucity of volcanic centres, the existing geological relations of Europe are undergoing comparatively little change—the gradual uprise of the Scandinavian coast, the alluvial formations at the mouths of such rivers as the Po, Rhine, Danube, and Dnieper, and the alternate inroads and sand-Atlantic, being the only appreciable phenomena.

315. As might be expected from the position, configuration, and surface-diversity of Europe, its climate is also varied and variable, without participating in those violent contrasts which mark most of the other continents. Lying almost wholly within the northern temperate zone (only a fourteenth of its area being within the arctic circle), a very small portion is uninhabitable on account of cold, while even on its most southern limit the heat is by no means excessive. The mean temperature of its southern border is about 66 degrees; and at Cape North, in lat. 71°, it is 32 degrees—a mean fully equal to what is experienced in North America between the parallels of 55° and 56°. On the whole, its mean temperature is higher than that of other regions within the same parallels, while in no part is it subjected to the same extremes of winter cold and summer heat. In fine, the climate of Europe partakes more of an *insular* than of a *continental* character; and this arises mainly from the circumstance that she is surrounded on three sides by the sea, and otherwise indented by inland seas and gulfs, so that no extensive portion of her surface is far removed from the tempering influences of the ocean. Besides this, her western shores are laved by the current of the Gulf Stream, which not only brings an additional store of heat, but wards off the cold approach of the northern iceberg; while the draining of marshes, clearing of forests, and other efforts of cultivation, have also tended to improve the climatic character of the country. The fact, also, that the lower part of Europe lies towards the north and the higher to the south, is not without its influence in modifying the climate; for had this been reversed—that is, had the Alps, Pyrenees, and Carpathians been situated in the north—more than a third of the surface would have been perpetually under snow and glacier and the rest would have been periodically chilled by their proximity.

316. Arranging the surface into climatic zones, the three following regions are usually enumerated:—1st, The *warm region*, where the lemon, orange, fig, olive, myrtle, and vine flourish, extending to the 45th degree of north latitude, and having a pleasant spring, a hot summer, and short mild winter. The countries within this belt have generally abundant rains during the last three months of the year, but are subject to great and long-continued droughts in summer. 2d, The *temperate region*, extending in the islands and seaboard to 55° north latitude, but in the interior perhaps not beyond 52°. In this region frost prevails two, three, or four months, and snow is common; the spring continues from April till June; the summer, the heats of which frequently rise to 92° Fahr., lasts till September; and the autumn the shortest season. 3d, The *cold region*, to the north, in which

beyond the 65th parallel, only two seasons occur—summer and winter ; the former lasting during June, July, and August, and the latter during the rest of the year. In this region the heat, during the brief summer, when the sun never sets, is very great, and the cold during the long winter proportionally severe.

317. In consequence of the principal mountain-chains being situated in the southern or warmer region, the climatic effects of altitude are less striking than in many other regions, though, as seen in Chap. XIII, the Alps and Pyrenees show various belts of vegetation, especially in their higher ridges. As the snow-line in Europe makes a very gentle curve from about 8500 feet in the Alps to 2000 feet at the North Cape, only very limited patches in the Alps and Dovrefelds come within its limit ; and hence, also, these are its only mountain-ranges that exhibit the phenomena of *glaciers*. As might be expected, the western side of Europe is the most humid, the number of wet days on the Atlantic seaboard averaging from 150 to 160 annually ; the southern or Mediterranean side is next in order, and averages from 90 to 100 days ; while in the centre and eastern districts a much smaller proportion (from 60 to 80) is experienced. On the whole, the climate of Europe is variable, but not excessive—fickle, but not insalubrious ; calling forth the utmost skill and watchfulness on the part of the husbandman, but never wholly disappointing his hopes or defeating his labours.

318. As might be expected from this diversity of climate, as well as from the diversity of physical aspect formerly alluded to, the vegetation of Europe presents considerable variety and complication—a complication which is greatly enhanced by the long-continued introduction of plants, useful and ornamental, from other regions. Referring to Chap. XIII. for matters of mere botanical interest, we may here briefly enumerate the range and limits of those fruits and vegetables that have more especially a useful or economic bearing. The dwarf-palm, cactus, and banana are found skirting some of the warmer portions of the Mediterranean seaboard. From this point north to the 45th parallel, the orange, citron, fig, pomegranate, olive, almond, myrtle, laurel, cypress, mulberry, vine, &c., flourish in perfection—some of these, as the vine, being profitably cultivated in sheltered valleys ; so far as the 50th degree. From the 45th to the 55th, the apple, pear, plum, cherry, apricot, and smaller garden-fruits are abundant ; and in the southern, middle, and western districts, as far north as the 60th parallel, the plane, chestnut, walnut, poplar, oak, ash, elm, beach, and other forest-trees, attain to perfect growth ; as do also wheat, barley, rye, oats, beans and pease, beet, turnip, and

ther bulbous roots, the potato, flax, and common cultivated grasses. In the central and eastern regions, where the climate is more decidedly *continental*, these plants find their limits at the 40th and 52d parallels, even in the lowest valleys. Forests of vine and birch continue in luxuriance as far as the 67th degree; at the 70th, oats and barley are the only kinds of grain which resist the rigour of the climate, though not always ripening; and beyond this the dwarf-birch and willow, the iceland and reindeer moss constitute the principal flora.

319. From the densely-peopled and cultivated character of Europe, its fauna (in all the larger animals at least) may be regarded more as a domesticated than a natural one. The true natural fauna is varied enough in point of species, but not important in point of size or number, and, with the exception of those the white bear, blue fox, reindeer, lemming, &c.) restricted to its arctic section, can inhabit indifferently any part of the country. This moderate climate, and the absence of great mountain and desert barriers, give a uniformity to the fauna of Europe which is not observable in other continents; and this uniformity is greatly augmented by the circumstance that the larger and more destructive animals are all but extirpated. But while the moderate and equable conditions of Europe have been unfavourable to the preservation of the native fauna, they have been specially favourable to the spread and crossing of the domesticated—and thus improved and improving breeds are to be found in every portion of its surface. Devoid of the larger carnivora and reptiles, of the brilliantly-coloured birds and insects that belong to warmer latitudes, the continent of Europe preserves, in an eminent degree, the elements and facilities for the cultivation of the useful and agreeable. In this way, partly from native and partly from exotic stocks, have arisen the many and valuable varieties of the horse, ass, ox, sheep, goat, and pig; of poultry—peacock, turkey, guinea-owl, barn-fowl, swan, goose, duck, pigeon, &c.; and in a less degree also of game birds, such as the grouse, ptarmigan, partridge, partridge, and pheasant. In this way, too, the temperate seas of Europe are stocked with inexhaustible supplies of wholesome fish, shell-fish, and crustacea, of which the cod, ling, tusk, haddock, turbot, sole, skate, salmon, sturgeon, tunny, herring, pilchard, mackerel, oyster, crab, and lobster, are among the most abundant and valuable.

320. On the whole, the geographical conditions of Europe,—its varied surface, numerous seas, and extensive sea-coast—its climate, mineral, vegetable, and animal productions,—eminently fit it for developing the enterprise and industry of its inhabitants.

And this development has been further fostered by the fact that all the finer southern and western portions are peopled by the more energetic Indo-European or Caucasian race, while the eastern and northern (or least valuable sections) are inhabited by families of Mongolian descent. Into the numerous families and tongues which time and the influence of external conditions have evolved from these two races, our limits will not permit us to enter; but it may be remarked that the Celtic, Teutonic, and Slavonian are the predominating sub-varieties—each embracing a vast number of minor nationalities and tongues, which are still acting and reacting upon each other in production of newer, and, on the whole, advancing stocks. The causes that regulate the growth and decay of nationalities is yet imperfectly understood; but however much may be ascribed to the inherent physiological peculiarities of race, there can be no doubt a vast amount depends upon the geographical or physical conditions of situation. In this respect the inhabitants of southern, central, and western Europe have had important advantages; and hence their superior civilisation, their progress in the arts and manufactures, and in all that relates to mechanical and commercial industry; and hence, also, their spread over a large portion of the New World and Australasia, whose aboriginal races seem destined to disappear before them.

Asia.

321. This anciently-peopled continent is by far the most extensive and diversified, the most compact in point of configuration, and yet, paradoxical as it may seem, the most widely separated in the character of its parts, of any of the so-called "quarters" of the globe. Situated between lat. $1^{\circ} 28'$ and 78° north, and long. 26° and 190° east, it occupies the greater portion of the eastern hemisphere, and presents an area estimated at 16,165,000 square miles, or more than four times that of Europe. A considerable portion of this is insular and peninsular, but not to such an extent as to interfere materially with the massiveness and continuity of configuration to which we have referred. Occupying three great climatic belts—tropical, temperate, and arctic—and exhibiting vast mountain-chains and lofty table-lands, broad grassy steppes and shingly deserts, luxuriant river-plains and tracts doomed to everlasting snow or scorching sterility, it is impossible to treat the continent as a whole, and hence it is usual to arrange it into northern, central, western, eastern, and southern sections—each having well-marked and distinctive features.

322. 1. Northern or Russian Asia, as observed in a former treatise, includes the whole of the continent north of the Altai and Yablonnoi Mountains—a region (as we descend from the mountains) of rocks and forest-growth, steppe-land and frozen tundra, bleak and barren, suffering from intense cold, thinly peopled, and almost physically incapable of improvement. Steppes affording a rough pasture in summer, and here and there capable of a rude cultivation; forests of pine and birch, gradually dwarfing to the north and east; and tundra or bog-moss frozen for ten months a year, and scarcely thawed to a foot in depth during a brief summer, are the leading features of this inhospitable section. 2. Central Asia, lying principally between the 30th and 50th parallels, embraces the lofty table-lands of Gobi, Mongolia, Tibet, and Eastern Tartary—a region of sandy deserts and salt lakes, diversified by mountain-knots that rise above the snow-line, and occasionally intersected by narrow valleys of considerable amenity. As the northern section was the region of frozen, so the central is the region of arid deserts, with this difference, that the more southerly position of the latter confers on its deeper valleys both verdure and fertility. 3. Western Asia, still exhibiting a series of plateaux, and partaking of the desert character of the central region, but less elevated and more broken up by hill-ranges and intervening valleys. On the whole, it is a hot and thirsty region, consisting largely of high sandy plains studded with numerous salt lakes, and but inadequately watered by rivers. The steppes of Western Tartary, the table-lands of Persia, and the deserts of Arabia, belong to this region—the finest portions being Turkey in Asia, Georgia, and the plains of the Tigris and Euphrates. 4. Eastern Asia, or that embracing the Chinese Empire, Mandshuria, and the islands of Japan, is one of the finest and most diversified sections of the great continent. The mountains of China and Mandshuria give to its western and northern portions an irregular and varied aspect, but its eastern consists of the great Chinese plain and low-lying region of vast extent and fertility. 5. Southern Asia, including Hindostan, Farther India, and the Malayan peninsula, and lying largely within the tropics, is decidedly the richest and most diversified region of the whole. Varied by minor hill-ranges and well-watered valleys, by deltas and river-plains, it enjoys a high though not oppressive temperature, has only a rainy season for its winter, and, except during long droughts in Central Hindostan, presents in every district an unfailling verdure.

323. The geological features of regions so vast and varied must necessarily partake of corresponding diversity; and though the geology of Asia is but imperfectly known, we have gathered enough

from recent surveys and travels to confirm the belief that every formation is there displayed, and this frequently on a most gigantic scale. Partaking of the arctic uprise of land in Siberia, having large rivers with gradually increasing deltas like those of the Indus, Ganges, and rivers of China, and being subjected in a remarkable degree to volcanic and earthquake disturbance in almost all its islands, as well in several parts of the mainland, its geological relations must be undergoing considerable modification, but not at such a rate as to interfere, for generations perhaps, with its general features. All the economic minerals and metals are found within one or other of its countries; the precious metals and gems also occur in abundance; and though less noted for its coal and iron than Europe or North America, it has still enough, in India, China, and Japan, to form the basis of a successful mechanical and manufacturing industry.

324. A continent stretching over three great geographical zones—tropical, temperate, and arctic—must necessarily exhibit great diversity of climates; and this diversity is rendered still more remarkable by the lofty table-lands, arid deserts, and snow-clad mountain-masses that occupy so large a proportion of the central regions. On the whole, as we have elsewhere observed, the continent of Asia does not enjoy the same modifying and tempering influences as Europe. A large proportion is situated on the confines of the polar circle, where, according to Von Wrangel, the winter's ice is gradually accumulating and overmastering the summer's heat; a still larger section is raised to an enormous altitude, and placed permanently under snow and glacier; its mass lies comparatively unbroken by intersecting and tempering seas; it has no burning sandy tracts in the south to send warm breezes, as the Sahara does to Europe; the Japan Current, whose genial waters lave its eastern coast, is of minor volume compared with the Gulf Stream; and even its southern or tropical districts are cooled by the winds that flow from the snow-clad central mountains. It suffers, therefore, what Humboldt calls an *excessive* climate—that is, excessively hot in summer and excessively cold in winter, or differing greatly during these seasons from the mean annual temperature. In other words, while the climate of Europe is more insular than continental, that of Asia is strictly and emphatically continental. As instances of its extremes, it has been remarked that grapes come to maturity on the borders of the Caspian, and yet the thermometer falls there in winter to 28° Fahr.; that at Tara, in Siberia, the temperature of the air in July and August rises to 82°, while a foot under the surface the soil remains permanently frozen; that in Arabia, after a night of hoar-

frost, the day-heat will often be as high as 114° Fahr.; that the snow-line in the Elburz is found at 11,000 feet, while in Tibet the mountains are clear at an elevation of 16,000 feet; and that while all the great central deserts are all but rainless, the annual rainfall in the lower plains of India amounts to 400 or 500 inches.

325. With a position so extensive, a contour so decided, and a climate so varied, we might naturally expect an abundant and diversified life, and in this respect, both vegetable and animal, Asia stands unrivalled among the other continents. If excelled in vegetable luxuriance by tropical America, it has at least greater variety of forms, while its animal life has a physiological power and completeness unapproached by other regions. Referring to Chap. XIII. for the general features of its vegetation, as governed by the great climatic zones, we shall here merely allude to those products which, like tea, are either peculiar to its soil, or which, from their value, become of industrial and commercial importance. Among its *fruits* may be mentioned the grape, orange, shaddock, lemon, lime, tamarind, mangosteen, fig, mulberry, olive, pomegranate, walnut, almond, cocoa, date, bread-fruit, cashew, betel, banana, pine-apple, melon, quince, apricot, peach, and all the garden fruits known in Europe; among *grains* and cultivated *roots*, maize, rice, wheat, dhourra, barley, pease, beans, lentils and other leguminous seeds, potato, yam, lotus, arrow-root, &c.; among *spices* and kindred products, cinnamon, nutmeg, clove, pepper, camphor, cassava, tea, coffee, sugar, sago, &c.; among *drugs, dye-stuffs, fibres*, and the like, indigo, arnatto, saffron, gamboge, galls, poppy, rhubarb, aloes, gums, hemp, jute, cotton, and many others; while among the *forest and ornamental trees* may be noticed the teak, cedar, sycamore, cypress, savin, mangrove, bamboo, banyan, plantain, cocoa and other palms, along with ebony, iron-wood, box-wood, sandal-wood, and others of a kindred nature.

326. It has been remarked by Guyot, that "as in the New World the vegetable kingdom has the preponderance over the animal, so in the Old World the animal has the preponderance over the vegetable. Not only are the representatives of the corresponding families larger and stronger in the Old World, but they appear in more numerous genera and more varied species, and even exhibit types entirely foreign to the New." In accordance with this opinion, it might naturally be expected that Asia, the largest and most diversified of the Old World continents, should have a fauna of corresponding variety and power; and thus it is that in all the zoological classes (with the exception, perhaps, of the reptiles and insects which dominate in tropical America) its animals excel both in nobleness of form and in numbers. Among the *mammalia*

may be noticed the apes and monkeys of the south; the lion, tiger, leopard, panther, ounce, and other felinæ of the south and west; the elephant, rhinoceros, and tapir of India; the wolf, hyena, jackal, blue and black fox, and numerous varieties of dog; the horse, ass, dzigettai, and camel of the central and western plains; the common ox, buffalo, auroch, yak, and musk-ox; the elk, reindeer, antelope, axis, argali, ibex, goat, sheep, muf-flon, &c.; porcupine, jerboa, marmot, lemming, beaver, bat, ermine, &c.; together with bears, badgers, gluttons, sea-otters, seals, sea-cow, and other cetacea. As her mammalia excel in variety, so also they excel in utility; and from Asia, as the original source, have other regions derived most of their domesticated and semi-domesticated animals, as the horse, ass, camel, elephant, ox, goat, sheep, pig, dog, cat; peacock, pheasant, barn-fowl, and other creatures so necessary to the comfort and luxury of civilised communities. Her seas, lakes, and rivers are stocked with valuable food-fishes, though less notably than Europe; red coral, mother-of-pearl, and pearls are fished from her gulfs; and among her special insect-products may be noted her silk, honey, bees-wax, cochineal, gall-nuts, lac, and other kindred substances.

327. Ethnologically the continent of Asia is occupied by three main varieties of mankind—the Caucasian, Mongolian, and Malay; the first inhabiting the south and west, the second the north and east, and the third the south-western region and adjacent Archipelago. Though each of these varieties embraces a vast variety of families and tongues—Hindoos, Persians, Syrians, Arabs; Chinese, Japanese, Mongols, Tartars; Burmese, Javanese, Polynesians—yet, on the whole, the physical peculiarities of the continent have kept them wonderfully apart, and thus each has enjoyed a own peculiar civilisation for ages. How little has China and Japan been influenced by India; how little has the civilisation of Japan reflected on Malaysia; and though Tartar and Kalmuck invasions from the north have been frequent enough on the south, how little impression have that of destruction, have they left on the plains of Persia and the deserts of Arabia! Mountains and deserts impassable than seas; and thus, altogether the geographical peculiarities of the Mongolian and Chinese has been none of that action and reaction, that absorption, that commingling and evolution of races has marked the progress of mankind across the seaboard of Europe. The civilisations have been more maritime than continental; those of the seaboard, than those of the interior. The one, in minor areas, has had a tendency to develop social

and complex relations; the other, in vast areas, and chiefly on far-separated river-plains, has been more productive of isolation and stationary individualism. "What has been wanting to the communities of Asia," it has been well remarked, "is the possibility of actions and reactions upon each other, more intimate, more permanent; it is the possibility of a common life. On the other hand, the smallness of the area, the near neighbourhood, the mid-land seas thick sown with islands, the permeability of the entire continent—everything conspires to establish between the European nations that community of life and of civilisation which forms one of the most essential and precious characteristics of their social state." It is thus that civilisation in Asia stands still or declines, while in Europe it is ever active and progressive.

Africa.

328. The next great "quarter" of the Old World is that of Africa, having an estimated area of 11,360,000 square miles, or, including Madagascar and the other islands, of 11,855,000. It lies between the parallels of 37° N. and 34° 50' S., and between long. 17° 30' W. and 51° 30' E.; being thus mainly tropical, and having only its northern and southern borders within warm-temperate latitudes. Separated from Europe by the Mediterranean, and but slenderly united to Asia by the low Isthmus of Suez, which is only 72 miles across, it is all but insular, and has consequently little of that community which marks the relations of Europe and Asia. The continuity of its coast-line is almost unbroken by seas, gulfs, or estuaries, and this resisting solidity of form is no doubt the chief cause of its interior being less known than that of any of the other continents. Even the disposition of its rivers is unfavourable to its penetration. The largest of them flow within its equatorial limits, and either debouch through swampy jungles, which is death for the white men to enter, or descend by cataracts and waterfalls inaccessible to navigation.

329. So far as we know of the physical peculiarities of the continent, it may be divided into four or five regions—differing in physical structure, but less in climate and vital aspects, than the regions of any of the other continents. Beginning with the north we have—1st, The mountainous district of the Tell lying between the Mediterranean and the Sahara, and composed largely of the Atlas chain, with its subordinate spurs and intervening valleys. Where the hills decline towards the Atlantic in Morocco the district is somewhat flat, but, generally speaking, it is hilly and

gular, with a warm but salubrious climate towards the Mediterranean, and a dry scorching one on the north, where it insensibly graduates into the Sahara. 2d, The region of the Sahara or Great Desert, which stretches from Marocco on the west to the Nile valley on the east—a hot and arid expanse, consisting partly of shingly plateaux resting on gypsum and largely impregnated with salt, and partly of dunes or ridges of drifting sand, the whole being marked at intervals by *oases* or fertile spots that enjoy the presence of a spring or runnel of water. The Sahara has thus its fertile and inhabited oases, its scrubby plateaux, and its shifting dunes of utter sterility. Its general character, however, is aridity and barrenness, and the oases merely appear like islets of verdure amid an ocean of desert. 3d, The Atlantic-coast region, a belt of luxuriant but unhealthy lowland, marked by numerous deltas and jungles along shore, but gradually rising and improving towards the interior. This region is rich in tropical forest-growth and verdure, but its pestilential climate has hitherto resisted all European approach, unless at a few very limited and unsatisfactory stations. 4th, The Southern or Cape region, which rises by successive hill-stages towards the north or unknown interior—these stages forming irregular terraces which are covered with grass after the rains, but become hard and bare, or but partially dotted with thorny scrub, during seasons of drought. On the whole, this region is hilly and irregular in surface, has a salubrious but arid climate, is by no means well watered by rivers, and is occasionally subject to destructive droughts. 5th, The Central region, which, so far as we can judge from recent discovery, partakes of the character of a high table-land, having numerous lagoons and creeks during the rains; but is wanting, on the whole, in rivers of permanent volume and navigable channels. Though strictly tropical, the elevation of this table-land confers on many portions the climate of temperate zones; and where water is present the country is described as fine and fertile, well peopled, and partially under a rude cultivation. The 6th and last region is that skirting the Red Sea, and comprising the hilly but not unfertile table-land of the Gallas and Abyssinians, the more stony and arid country of Nubia, and the alluvial valley and delta of Egypt. This region is remarkable for its fine but somewhat arid climate; its fertility where water is present; and, ethnologically, for the early and peculiar character of its civilisation.

330. Geologically we know little of the formations of Africa, and hitherto the continent has contributed less to the mineral and *metallic* wealth of the civilised world than any other region. The whole of the Sahara is but the upheaved bed of a tertiary, or even

lternary ocean; the deltas of the Nile, Niger, and other great rivers, consist of recent alluvia; the formations of the Cape are chiefly mesozoic sandstones; the northern belt consists largely of soft tertiary limestone; the primary hills of Abyssinia and Nubia are known chiefly for their granites and porphyries; and most of the islands, whether in the Atlantic or Indian Ocean, are of recent volcanic origin. The great interior is unknown, but, judging from information as well as from native ornaments and report, iron, copper, gold, and silver must exist in its mountains.

331. As already observed, the greater portion of the continent lies within the tropics, and must necessarily partake of the climate peculiar to the torrid zone. The Cape region and the region of the Tell are the only parts enjoying warm-temperate or sub-tropical conditions, and even these are more or less influenced by the excessive climate that pervades the interior. "It is only that strip of Barbary," says Balbi, "which the Atlas protects from the hot winds of the desert, and that part of Hottentotland protected by the Nieuyeldt and other mountains near the Cape, that enjoy the advantages of countries situated within the temperate zones. With the exception, therefore, of these small and narrow tracts, of those regions in the interior to which their elevation imparts the coolness of higher latitudes, and of the borders of the great lakes and rivers (see Captain Speke's experiences, 173), every part of Africa is burnt up by continual heat, and the continent generally may be regarded as the warmest region of the globe. Nothing moderates the heat and the dryness but the annual rains, the sea-winds, and the elevation of the soil; while in the well-watered regions, the moisture combined with the heat, though productive of the most luxuriant vegetation, are extremely deleterious to man."

332. As might be expected from the tropical position and generally hot and arid climate of Africa, its vegetation is more unique and much less varied than that of Europe or Asia. Along the Mediterranean seaboard and the lower valley of the Nile, the vegetation greatly resembles that of southern Europe, with a greater tendency, perhaps, to tropical forms. Wherever soil and water can be obtained, rice, maize, wheat, lentil, and millet; the grape, orange, fig, olive, and date; cotton, flax, and tobacco, can be grown to perfection, and often, as in Lower Egypt, yield large returns. The Sahara, where vegetation is possible, is characterized by its prickly shrubs, brooms, pistachios, tamarisks, ephedras, and dry tufty stupa grass, while in its oases the date-palm is the indispensable product, having, as the Arabs say, "its feet in water and its head in fire." In Upper Egypt and the highlands of Nubia and Abyssinia, the characteristic plants are gum-yielding

white-ant, scorpion, tsetze-fly, &c.), are chiefly destructive and pestilential; and she possesses few or none, like the silkworm, the bee, and the insect, of commercial utility.

The inhabitants of Africa (laying aside English, Dutch, French, and other European settlers) belong chiefly to the Caucasian branch of the Caucasian variety in the north, and wholly negro or Ethiopian variety in the central and southern parts. The Semitic or Syrio-Arabian stock embraces the Egyptians, the Copts, the Abyssinians, Nubians, Arabs, Berbers, Moors, and other families arising from their admixture; the Negro variety embraces, on the other hand, the whole of the dark-coloured races.—Gallas, Fellatah, Jalofes, Mandingoes, Krus, Ashantees, Conzulus, Kaffirs, Hottentots, Bosjesmen, &c.—that people the continent from the Sahara to the Cape. Unless within the European settlements, civilisation in Africa is at a very low ebb. The Moors and Arabs, though active traders, are but in a state of semi-civilisation: their manufactures in silk, cotton, linen, leather, and the like, are rude; and their commerce, carried on chiefly by caravan, is limited and uncertain. The negro races, on the other hand, though some tribes indulge in barter, others keep herds, and some even attempt a primitive agriculture, are not, as a whole, raised beyond the level of barbarism. The inherent qualities of the race are evidently inferior; and whether it is capable of amalgamating with the white, of being taught and elevated by its example, or is doomed ultimately to disappear before it, are problems yet to be solved by the ethnologist. On the whole, the habitat of the true Negro seems to be strictly intertropical; under its fiery sun he is robust, hardy, and lively; beyond it he becomes enfeebled, and degenerates. The heat, however, that develops the Negro enervates the white, and this circumstance may yet reserve for the race an equatorial zone in which it may attain to a limited and semi-dependent civilisation.

North America.

335. This great section of the New World bears much the same relation to the western hemisphere that Asia-Europe does to the eastern; while South America holds a somewhat analogous position to Africa. Like Europe and Asia, North America lies chiefly within the northern temperate zone; has its coast-line well diversified by bays, gulfs, peninsulas, and promontories, and has also numerous outlying islands. South America, on the other hand, lies, like Africa, mainly within the tropics; is also slenderly united

to the North by a narrow peninsula ; has a coast-line little broken by indentations ; and has, in like manner, fewer and less important islands. Unlike the Old World, however, the trend of whose main mountain-masses are latitudinal, the New World has its mountain-chains arranged longitudinally ; and this disposition, of course, confers on its surface many important distinctions, both physical and vital. On the whole, the continent of North America enjoys temperate position, extent of coast-line, ready access to its interior by bays, lakes, and rivers, and at the same time comparatively easy communication between all its parts, from the absence of impassable deserts or insurmountable mountain-barriers.

336. Physically, the continent may be arranged into the following regions, the nature of which, with slight modifications, are thus given by Malte Brun and Babli :—1. The narrow region of Central America, which lies between the Gulf of Mexico and the Pacific, and is traversed throughout its whole length by mountain-ranges, which leave but a strip of low land along the sea-coasts, while in certain portions of the interior they form (par. 86) elevated table-lands. This region is strictly intertropical, and, along with the West India Islands, is marked by a tropical flora and fauna, unless in the more elevated portions of the interior. 2. The maritime region, extending from the extremity of the Californian peninsula northwards to Aliaska, and from the shores of the Pacific inland to the ridge of the Sea Alps. This region has a fair climate, but is hilly, irregular, and cut up by numerous cross-gorges from the mountains. 3. The elevated region which forms a sort of table-land between the Sea Alps on the west and the Rocky Mountains on the east. In its southern portion it presents the arid salt plains of the Californian desert ; between 40° and 45° with it presents a somewhat fertile desert ; but beyond the last-mentioned parallel it becomes barren and inhospitable. 4. The central plain of the Missouri and Mississippi (par. 94), extending from the Rocky Mountains on the west to the Alleghanies on the east, and from the Gulf of Mexico northward to the 50th parallel. On the west this region is rich and well wooded ; in the middle it is open or rolling prairie-ground, but not unfertile ; but towards the west it is dry, sandy, and almost a desert. 5. The northern declivities of the Alleghany Mountains and the maritime region extending to the shores of the Atlantic. This is a region of forests, of mixed but rather poor soil, and with considerable tracts of swamp-land in the south. 6. The great north-western region, beyond the parallel of 50° , dotted on its southern limits with forests, but beyond this, for four-fifths of its area, a bleak waste, overspread with numerous lakes, and resem-

bling Siberia in the physical character of its surface and the rigour of its climate. 7. To these may be added (though not belonging to the American continent) the frozen region of Greenland and the Arctic islands—a division of the globe doomed to perpetual snow, ice, and glacier, and whose wealth arises more from the temporarily open seas that surround it, than from the land of which it is composed.

337. Geologically, this continent presents every stratified formation, from the old crystalline schists of St Lawrence and the Appalachians down to the recent alluvia of the Mississippi, and from the granites, syenites, and porphyries of the Rocky Mountains down to the recent ejections of the Mexican volcanoes. The great central plain, from the delta of the Mississippi north to the Arctic Ocean, is chiefly of recent origin, and consequently yields comparatively few mineral or metallic treasures; but in the other regions the economic minerals are numerous and abundant. Of these may be mentioned—granite, and building-stones of every description; limestone, marble, magnesian limestone, and gypsum; salt and salt-springs in great abundance, and from several formations; coal, both anthracitic and bituminous, in inexhaustible fields in the United States and Nova Scotia; asphalt, pitch, and petroleum springs; roofing-slate, whet-slate, and other minor minerals. The chief metals are—gold in California, British Columbia, Mexico, and the Carolinas; silver in the Central States and Mexico; iron in the United States, Canada, Mexico, and other districts; copper abundantly in the United States, Canada, and the far north; lead also abundantly in the Western States and Canada; and tin, mercury, and antimony in Mexico.

338. As will be seen by a glance at the sketch-map of isotherms, the climate of North America is greatly inferior to that of the Old World within corresponding parallels of latitude. The great extent of surface that lies within the arctic zone, the solidity of the mass, unbroken by the tempering influence of seas, the flow of the arctic current that chills so much of its eastern seaboard, the amount of forest and undrained lands, and the cold aërial currents that pass from the frozen lake-region of the north over the interior, all conspire to diminish the temperature that normally belongs to its geographical position. This diminution is estimated to be about 10° Fahr., as compared with the temperature of the same parallels in the west of Europe. The western or inland seaboard, however, is much warmer than the eastern of the same parallel; but this influence is little felt beyond the range of the Sea Alps, and does not tend to mitigate the northern currents that reduce the temperature of the interior. Altogether

North America possesses a true continental climate—severe winters and warm summers; and from this circumstance it has been supposed that it will be impossible to carry the arts of civilised life much beyond the 56th or 58th parallel, latitudes within which are situated the capitals of Norway, Sweden, and Russia.

339. Compared with the Old World, the New World excels in the exuberance of its vegetation. The breadth of its plains, the humidity of its atmosphere, and its rich and well-watered soil, confer on it a verdure—a “leafness,” as it has been termed—not to be found in the flora of the Old. From the Isthmus of Panama north to the 27th parallel, the vegetation (with the exception of that on the higher table-lands) is altogether tropical; and hence all the low grounds of the West India Islands and Central States teem with the products of that zone.* From the 27th north to the 35th parallel is the warm-temperate zone of the continent, marked by its magnolias, swamp-hickories, lobelias, deciduous cypress, and luxuriant climbers and aquatics; and between the 35th and 44th parallels may be said to lie the true temperate zone, characterised by its oaks, ash, hickory, plane, white cedar, sassafras, cornel, yellow birch, red maple, fine flowering climbers and aquatics, and growing in perfection all the cultivated fruits and grains. North of the 44th parallel to the basin of the St Lawrence and Canadian lakes stretches the colder-temperate zone, with its oaks, elms, birches, maples, red and white pines, and the ordinary fruits and grains of temperate Europe; while northward and beyond lie forests of pine and fir, that gradually give place to the dwarf willows and birches of the arctic regions. In an economic or agricultural point of view, it may be stated that all the common garden fruits of Europe can be reared in the northern states of the American Union; while oranges, pomegranates, melons, figs, peaches, grapes, olives, almonds, &c., can be grown in the south. Indian-corn is cultivated all south of Maine, tobacco as far north as 40°, cotton to 37°, the sugar-cane to 32°, rice in the Gulf States, wheat all over the Union, oats and rye chiefly in the north, and hemp, flax, and hops in the western and middle districts.

* “The rich and varied productions of the West Indies,” says a recent authority, “give them an important place in the commercial world. To their valuable native plants, art and industry have added others not less valuable. The sugar-cane, yielding its threefold tribute of sugar, molasses, and rum; the coffee-plant, pimento, or allspice; the plantain and the banana; the pine-apple, anona, yam, sweet-potato, maize, cassava, manioc, with cacao, tobacco, and cotton; various dye woods and stuffs, as fustic, logwood, indigo; medicinal plants, as liquorice, arrow-root, ginger, jalap, ipecacuanha; building and cabinet timber, as mahogany, *lignum vitæ*, and cedar; to which list may be added the bread-fruit, cocoa, mango, papaw, guava, orange, lemon, tamarind, fig, and other tropical fruits.”

40. It has been already stated that while the New World excels in the exuberance of its vegetable forms, it falls far behind the Old in the variety and importance of its animals, the reptiles and insects alone excepted. Many of the higher forms are altogether wanting, others are but feebly represented; while, generally speaking, there is a greater paucity of specific variety even in the lower forms that occur. Whatever may have been the condition of the New World during geological times, it is certain that since the present era it had no native horse, ass, zebra, or other equine species; no giraffe, camel, or dromedary; no elephant, hippopotamus, rhinoceros; no useful ruminants comparable to those of Europe and Asia; and though the puma, jaguar, and ocelot may represent the lion, tiger, and leopard, there is a feebleness and want of numerical abundance even in these, as compared with feline and carnivorous animals of Asia and Africa. Besides these, other Old World forms have their representatives, but still inferior in power and numbers—as, for example, the camel by the llama, the marsupials of Australia by the opossums, the ostrich by the rheas, the crocodile by the alligator, and so on of other orders. In like manner the monkeys of the New World are inferior to those of the Old; the native red man also is less robust, less hardy, and less lively than the black man of the Old; and thus, while the latter has thriven and multiplied even under toil and oppression in the New, her own aborigines have dwindled and died at the sight of industry and application. From the proximity of the continents perhaps, there is a stronger resemblance between the fauna of North America and that of Asia-Europe than there is between those of South America and Africa, though both are chiefly tropical; and hence such forms in the north as the Esquimaux dog, the lynx, wolf, fox; polar, black, and grisly bears; badger, otter, beaver, ermine, bison, elk, reindeer, moose, red, and other deer. It is chiefly from this cause that all the domestic animals of the Old World—horse, ass, camel, ox, sheep, goat, pig, dog, cat, poultry, and the like—have been introduced with such success in North America, and have spread with the colonists over every habitable region of the continent.

341. Referring to Chap. XV. for the characteristics of the aborigines of the New World—the American or red variety of mankind—we may here remark that at the time of its discovery in 1492, North America was inhabited chiefly by *Indian* tribes, who led a savage life, and obtained their subsistence by hunting and fishing, having neither herds nor flocks, nor even attempting the rudest forms of agriculture; by the *Aztecs*, a civilised offshoot of the race who inhabited the Mexican table-land, and had made

considerable progress in the arts; and by the *Esquimaux* (of Mongolian descent), who peopled, as they do now, the shores of the northern seas, and subsist wholly by fishing. Since then the continent has been colonised and peopled principally by Europeans (we exclude the African negroes imported as slaves, and their half-breed progeny), Spaniards in Mexico and the West Indies, French along the St Lawrence and Mississippi, British, Dutch, and Germans originally along the eastern seaboard, but now over the whole habitable surface, insular and continental. From these, and from their admixtures, have arisen what may be termed the Anglo-American family, before whose advance the native tribes are rapidly disappearing, and who, carrying with them and still enjoying all the advantages of European civilisation, are gradually laying the foundation for newer phases of progress, in conformity with the special conditions of their continent. We say *phases*, for the continent is too large, and its geographical conditions and consequent industry too diversified, ever to be governed by a single and uniform rule; and in all likelihood before many generations pass away, Mexico, the Pacific States, British America, the New England States, the Gulf or Southern States, and the Great Central Plain, will each be the seat of an independent community—connected, it may be, by commercial ties and reciprocating international offices, but still individually influenced by their position, and progressing at different rates and in different ways, and this in a great measure according to the nature of their material surroundings.

South America.

342. United to North America by the narrow Isthmus of Panama, which is little more than eighteen miles across, South America, like Africa, stretches away into the southern hemisphere, bulking broadly beneath the equator, but gradually tapering till it terminates in the bold rocky promontory of Cape Horn. Extending from lat. 12° north to 56° south, and from long. 25° to 82° west, it has an estimated area of 6,820,000 square miles, fully two-thirds of which are situated within the tropics. Like Africa, its triangular outline is little broken by gulfs or bays; but, unlike that continent, it has a gigantic river-system, whose estuaries and channels afford the means of communication with its remotest interior. All its better portions are thus fairly accessible—the only barrier being the lofty ridges of the Andes (practicable only at a few narrow passes), which separate the eastern plains from the

western seaboard. If we except the West Indies, which have been noticed in connection with North America, it has few contiguous islands, and these are comparatively small and of little importance.

343. In physical aspect the continent has been arranged by the authors of the 'New York Atlas' into the following regions:—

1. The low-terraced belt of country skirting the shores of the Pacific, from 50 to 150 miles in breadth and 4000 in length, of which the two extremities are fertile, and the middle sandy, arid, and dotted with salinas.
2. The basin of the Orinocco, enclosed by two divergent branches of the Andes, and consisting of extensive plains, called *llanos*, either destitute of wood or merely dotted with trees, but covered during part of the year (the rainy season) with luxuriant herbage.
3. The basin of the Amazon, a vast plain, embracing a surface of more than 2,000,000 square miles, intersected by numerous tributary rivers, possessing a rich soil and humid climate, almost entirely covered with dense forests (*selvas*) and impenetrable jungle-marshes by the river-sides.
4. The great valley of the Plata, occupied chiefly by open plains called *pampas*, in some parts (towards the Andes) barren and shingly, but in general covered with weeds, thistles, and tall grasses, on which feed prodigious herds of wild horses and cattle.
5. The high country of Brazil, eastward of the Paraña and Uruguay; presenting alternate ridges (*sierras*) and valleys, covered with wood towards the Atlantic, but opening into *steppes* in the interior.
6. The sterile region of Patagonia, rising by successive stages from the Atlantic—the soil shingly and strewn with boulders, the grass stunted, and the climate cold and tempestuous. And, lastly, the Andean belt, stretching from south to north, consisting of mountain-ridges covered with snow and volcanic ejections, and of intervening gorges and occasional table-lands, whose elevations confer on their tropical position the climates of temperate regions.

344. Though observations have been made at numerous detached points, the geological structure of the continent is yet imperfectly known. It has been ascertained, however, that the great plains above alluded to are of tertiary or post-tertiary origin; that primary and secondary formations occur in Brazil, Guiana and Columbia; that a considerable portion of the Pacific seaboard is of recent upheaval; and that within the range of the Andes there are vast exhibitions of crystalline and silurian schists, granites, porphyries, felstones, and other igneous rocks, down to the most recent scoræ and lavas. The Andes, as well as Brazilian and Columbian sierras, are also rich in metalliferous veins and

precious minerals, and, laying aside the recent discovery of the Californian and Australian gold-fields, no other continent has yielded so long and so plentifully such valuable supplies. Gold, for example, is found in New Grenada, Brazil, Chili, Peru, and Bolivia; silver in Peru, Bolivia, Chili, and La Plata; tin and quicksilver in Peru; copper, lead, antimony, iron, &c., in various districts; coal in Brazil, Chili, and Panama; salt in Grenada and La Plata; nitrates of soda and potash in the salinas of La Plata and Peru; diamonds in Brazil; emeralds and other precious stones in most of the higher regions.

345. With the exception of Tierra del Fuego and Patagonia, which are chilled by the cold currents from the Antarctic Ocean, and the plain of La Plata, which, towards the Atlantic, enjoys a genial and temperate climate, the great bulk of South America is situated within the tropics, and would consequently be subjected to the uniform temperature of that zone, were it not for the widely different elevations of the surface. These altitudes are not, as might be supposed, tantamount to belts of latitude, but are productive of peculiar climatic results, which are thus graphically described by Malte Brun:—The three zones of temperature which originate from the enormous difference of level between the various regions, cannot by any means be compared with the zones which result from a difference of latitude. The agreeable, the salutary vicissitudes of the seasons, are wanting in those regions that are here distinguished by the denominations of frigid, temperate, and torrid. In the frigid zone, it is not the intensity, but the continuance of the cold, the absence of all vivid heat, and the constant humidity of a foggy atmosphere, that arrest the growth of the great vegetable production, and in man perpetuate those diseases that arise from checked perspiration. The hot zone of these places does not experience excessive heat, but it is a continuance of the heat, together with exhalations from a marshy soil, and the miasmata of an immense mass of vegetable putrefaction, added to the effects of an extreme humidity, that produces fevers of a more or less destructive nature, and spreads through the whole vegetable and animal world the agitation of an exuberant but deranged vital principle. The temperate zone, by possessing only a moderate and constant warmth like that of a hothouse, excludes from its limits both the animals and vegetables that delight in the extremes of heat and cold, and produces its own peculiar plants, which can neither grow above its limits, nor descend below them. Its temperature, which does not brace the constitution of its constant inhabitants, acts like spring on the *diseases* of the hot regions, and like summer in those of the frigid

Accordingly, a mere journey from the summit of the Andes level of the sea, or *vice versa*, proves an important medical which is sufficient to produce the most astonishing changes in the human body ; but living constantly in either one or other of these zones must enervate both the body and the mind by its monotonous tranquillity. The summer, the spring, and the winter are seated on three distinct thrones which they never quit, and are constantly surrounded by the attributes of their power.

6. As might be expected from its vast river-plains, tropical climate, and excessive humidity, the continent of South America is unrivalled in the luxuriance of its vegetable life. In no other is the true tropical forest seen in such perfection, in none is the rapidity of growth so remarkable, and in none is there such an outpourment of verdure and foliage. Here is the great headquarters of the palms and melastomas—the former, in numerous genera and species, spreading over an area of nearly 600,000 square miles. The Amazonian selvas and Brazilian forests present, as we have formerly remarked, the most luxuriant and gorgeous growth of lianas and tree-ferns, tangled with rope vines and other parasitical members, and studded with the strangest forms of the orchids. There also flourish the mahogany and other timber trees ; the dyewoods of commerce ; the siphonia or india-rubber tree ; the Brazil-nut, vegetable ivory, and castor-bean ; the banana, anana, pineapple, agave, guava, custard-apple, cassava, pepper-plants, and actuses of innumerable species, yams, potato, arrow-root, &c. ; while the river-creeks are covered with the most gorgeous floaters, among which is the celebrated Victoria Regia of Sir Robert Schomburgk. The higher grounds of Peru and Bolivia are the headquarters of the cinchonas or medicinal barks ; the escallonias and calceolarias ; and there also flourish the milk-tree, the courbaril or copal-tree, and araucaria. In Paraguay is grown the maté or Paraguay-tea tree ; and in the more tropical portions are cultivated the sugar-cane, coffee, cocoa, chocolate, tapioca, arrow-root, indigo, tobacco, cotton, and a thousand luscious fruits ; while in Chili, 'the Italy of South America,' are grown the vine, olive, and European fruits."

347. But while the vegetable element predominates, the animal is subordinated ; and, as formerly stated, the fauna of South America is greatly inferior, both in importance and variety, to that of the Old World continents, or even to that of North America. Its tropical regions excel, it is true, in the intensity of their vegetable and insect life, but in all the higher orders there is a remarkable paucity compared with its area and vegetation. The monkeys, though in myriads, are inferior to the ourang-outan

temperament and habits of the Old World; its bats are numerous, but not so many as in the Indian Archipelago; its chief caracaras are the *tyto*, *scops*, and *scops*, representing the lion, the leopard, and the tiger of Asia and Africa; its gnawers

are everywhere abundant; its small mammals are the *spiz*, and some small species of deer, there being no *capreolus* or *capreolus* in the country like the ox, sheep, goat, &c. of the Old World. The *armadillos*, ant-eaters, &c.) are everywhere in the country. The only important pachyderm of the country is the *tapir*, and the most important the opossum. All its domestic animals—the *cow*, *sheep*, *pig*, *dog*, *cat*, *poultry*, &c.—are imported from the Old World; the only animal it has furnished to Europe being the *tapir*, whose naturalisation in Europe has not yet been successful.

The *Indians* of the country are the *Indians* of South America, of various nations and languages. Originally inhabited by the *Indians* of the *Andes*, some of whom, like the *Toltecs* or *Azacs* of *Past* and *South*, had made considerable progress in civilisation, it is now partly peopled by *Indians*, partly by *negroes*, partly by *Europeans*—*Spanish*, *Portuguese*, *British*, *French*, *Irish*, &c.—and largely by a mixed race that has arisen from the intermixture of these varieties. Although there is a large infusion of the *Spanish* and *Portuguese* element, the coloured races are still the most numerous, and all the other—*English*, *French*, *North Americans*, &c.—may be regarded as *traders* and *adventurers*, rather than *settlers* in any of the so-called *republics*. In this way, though civilisation is extending, it has by no means made satisfactory progress. Little has been done, or is doing, in the arts and manufactures; and the industry of the inhabitants is chiefly directed to raising and collecting raw produce—minerals and metals: *hides*, *skins*, *tallow*; *woods*, *dye-stuffs*, *medicinal barks*, *india-rubber*, *fibres*, *gums*; *sugar*, *coffee*, *cocoa*, *fruits*, and *farinaceous products*—for shipment to Europe. The continent, however, has numerous and noble facilities; and since the establishment of more frequent communication with the United States, the introduction of steam navigation in her rivers, and the adoption of more perfect mechanical means, we may naturally look forward to the infusion of elements of immigration, more permanent settlement, and, consequence, better government, and more satisfactory pro-

Oceania.

349. This term has been applied by modern geographers to the numerous islands that are scattered over the bosom of the Pacific and Southern Oceans. Embracing the Indian Archipelago, Australia and adjacent islands, and the truly pelagic groups of the Pacific, its limits may be said to extend from lat. 50° south to 30° north, and from long. 96° east to 150° west in the opposite hemisphere. Its land area has been roughly estimated at 4,200,000 square miles, the greater bulk of which is intertropical, and, consequently, characterised by the climate and products of the torrid zone. It is usual to arrange the whole into several sections (par. 38), but the following—Malaysia, Australasia, and Polynesia—are sufficient for our review, it being borne in mind that the further the groups are removed from the continents on either side the Pacific, the more peculiar do they become in their climatic and vital aspects.

350. Of the first great section, *Malaysia*, which includes the whole of the Indian Archipelago, and lies between lats. 12° 40' south, and 20° north, it may be remarked that, being strictly intertropical, and separated from the mainland of Asia only by the narrow Strait of Malacca, the Chinese Sea, and Strait of Formosa, it partakes largely of the characteristics of Further India. Consisting of several large islands (Borneo, Sumatra, Java, Celebes, Luzon, &c.) and of minor clusters and chains intersected by narrow straits and intricate channels, its position and configuration are extremely diversified; while its contour is rendered boldly irregular by numerous lines of volcanoes, extinct and active, many of which rise from 6000 to 10,000 and 12,000 feet in height—the culminating altitude being Singalang in Sumatra, 15,000 feet. Hilly and irregular, there are no plains deserving of the name; insular and humid, there are no arid deserts; and, lying directly under the equator, the lowlands abound in jungle and unhealthy swamp, while the uplands are covered by magnificent forest growth. As might be expected from the proximity, its vegetable and animal productions, with a few exceptions, are specifically the same as those of the tropical mainland; hence the following form the principal exports of the Archipelago:—In the *mineral* kingdom, gold, tin, antimony, bismuth, copper, iron, coal of good quality, diamonds, emeralds, and other precious stones; in the *vegetable*, nutmegs, cloves, cinnamon, pepper, ginger, and other spices, coffee, sugar, gums, camphor, cocoa, betel, areca-nuts; in the *animal*, tobacco, cotton, and other fibres; maize, rice, sago, cassava, bre

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though the explorers who recently crossed the continent from south to north occasionally met in with wooded and grassy flats, the journey on the whole was through a shingly, scrubby, and waterless country. Tasmania, which occupies an area of about 24,000 square miles, has more hill and dale than Australia, is better watered, and altogether a milder and finer country. New Zealand, which consists of three contiguous islands, about 1100 miles in length, and varying from 5 to 200 miles in breadth, has from its latitude a still more temperate climate, at least in all the low grounds and along the seaboard (for on the higher elevations it is often cold and stormy); is also more hilly and irregular in surface as well as in shore line; and has moreover a copious supply of water.

353. All of these settlements (Australia, Tasmania, and New Zealand) exhibit a variety of geological formations from the old gold-bearing schists down to the most recent gravels, coral-reefs, and volcanic ejections. They are especially rich in the useful minerals and metals—gold, copper, iron, coal, limestone, marble, jade, and building stone; and these supplies must naturally contribute to their future progress, as they have already done to their rapid colonisation. Though devoid of the rich and varied vegetation of tropical regions, they are well supplied with useful timber trees, species of *araucaria*, *eucalyptus*, and *casuarina* (the Norfolk-pine, blue-gums, iron-barks, stringy-barks, swamp-oaks, &c., of the settlers) being numerous and characteristic; while all the cultivated grains, fruits, and vegetables introduced by the European settlers, from the vine, olive, and peach down to the humblest garden produce, can be grown to perfection. With the exception of the dingo or native dog of Australia (the aboriginal existence of which is even problematical), there were no mammals in Australasia at the time of its discovery beyond kangaroos, opossums, wombats, and other marsupial genera. All the domesticated animals have been introduced by the settlers; to whom, and to the Acclimatisation Society of New South Wales, the region is also indebted for the naturalisation of many of the song-birds, useful insects, and fishes, of the other continents. Of course, in matters of this kind, whether vegetable or animal, the different colonies will be ultimately governed by their geographical position and climate—that which is practicable in New Zealand being impracticable in New South Wales, and what is possible in Southern Australia being impossible in the northern and tropical latitudes of *Carpentaria*.

354. Ethnologically, the aborigines of the different islands of Australasia are regarded as widely different families of the Malay

race—the dark and savage Papuans of New Guinea and adjacent islands, the feebler and wandering tribes of Australia, and the active, daring, and more intelligent Maories of New Zealand, being the principal offshoots. As yet the Papuans have been little interfered with; the Australian tribes are rapidly disappearing before the advances of the white settlers; and though the Maories have shown more aptitude to imitate, and greater boldness to resist, there can be little doubt that they too must shortly succumb to the influences of a higher civilisation. All the colonies of Australasia belonging to the British, the settlers are principally English, Scotch, and Irish, with a slight infusion, however, of other Europeans, and even Chinese, attracted by the lottery of the gold-fields. As the British element so greatly predominates, with British laws, manners, and appliances, and with, moreover, the most intimate intercommunication with the mother country, the current of Australasian civilisation may be said to run parallel with that of Europe, and can only, after the lapse of generations and the influence of new geographical conditions, be expected to exhibit peculiarities of its own. In the mean time, with their wide pasture-runs, gold-fields, coal-fields, iron-mines, copper-mines, and the facilities of steam communication, the colonies of Australasia are making rapid material progress; and it may be fairly questioned whether, since the establishment of New South Wales in 1788, and of the other provinces since 1828, any settlements under British rule ever exhibited, with less trouble and expense to the mother country, an equal amount of satisfactory and hopeful advancement.

355. *Polynesia*—the usual term employed to designate the numerous islands that stud the bosom of the Pacific within 30 degrees on either side of the equator—embraces the Sandwich, Ladrões, Marquesas, Society, Friendly, Feejee, and other groups, with many other minor clusters and solitary islets that have scarcely a name. Many of these islands, like the Sandwich, Society, and Marquesas, are of volcanic origin, and are still the seats of the most gigantic igneous eruptions; some have old volcanic foundations surmounted and surrounded by upheaved coral-reefs; while others are mere coral-reefs more or less elevated above the level of the ocean. Many of these are extremely irregular in surface, and some, like the Sandwich volcanoes, rise to great altitudes (2,000, 12,000, and 16,000 feet); but, being generally of small dimensions, there is wanting that breadth of surface necessary to the formation of rivers, plains, and other features of geographical Being of recent geological origin, they afford no mineral wealth, and their main value lies in their fine climate

and the fertility of their soil. Situated within the tropics, but tempered on all sides by the ocean, by the constant aerial currents which are scarcely interrupted by their dimensions, as well as by their frequent elevation of surface, their climate is said to be delightful, though somewhat enervating and monotonous. Their native productions are the cocoa, bread-fruit, banana, plantain, taro, yam, batata, and other tropical fruits and roots; while the orange, lemon, sugar-cane, cotton, potato, melon, guava, and the like, have been successfully introduced, and flourish luxuriantly in all the larger islands. When first noticed by Europeans there were no quadrupeds on any of the islands save hogs, dogs, and rats (and these may have been the produce of stocks left by previous vessels); but now the horse, ox, goat, sheep, pigs, poultry, and other domestic animals, have been introduced into the larger islands. Most of the islands abound in birds, the shores in sea-fowl, and the waters in fishes, crustacea, turtles, seals, and cetacea.

356. The natives scattered over Polynesia seem offshoots of the Malay race, and though utterly uncivilised, idolatrous, addicted to cannibalism and other barbarous vices, are yet, on the whole (apparently from the unvarying nature of their climate, easy means of subsistence, and isolation), comparatively mild and tractable in their dispositions. This has led to some degree of civilisation in the Sandwich, Society, and Friendly Islands, chiefly through the exertions of British, French, and American missionaries; but as yet to little of that kind of progress which indicates the existence of an inherent and self-sustaining power of improvement. Indeed, it may be questioned how far the limited areas of these islands, the distance of the groups, the want of minerals and metals, the enervating effects of climate, and the easy means of subsistence, will permit of more than a dependent condition of civilisation to the inhabitants of Polynesia.

357. Such are the principal land-areas which form the themes of Physical Geography—the store-houses of the minerals and metals, the stations of the vegetable and the habits of the animal kingdom, and thus the varied and inexhaustible fields of human industry and civilisation. Consisting of different geological formations, they possess different minerals and metals; and in different positions, configurations, and contours, they enjoy different climates, and, consequently, produce different vegetable and animal substances. These differences give rise to actions and reactions, physical and vital—for it is only where differences exist

activities are excited—and in this manner are produced the whole round of phenomena that form the sum and substance of cosmical progress. In the physical world, from the revolution of the planets down to the simplest chemical combination, we see and believe that the whole is the result of law and law-directed forces; and in like manner, in the intellectual world, we may rely, though we cannot always determine, that all the phenomena of civilisation are under the direction of laws as pervading and imperative. To observe and arrange the phenomena of the terraqueous surface, to discover their producing causes, and to give intelligible expression to the law that regulates, is the great object of our science, and it only partially performs its function when, in dealing with the human species, it fails to be guided by the same methods of research. Directed by these methods, and applying them to the whole field of nature, the ordinances of our planet, amid all their myriad ramifications, assume a unity and completeness which it is the great object of science to discover and the highest effort of Philosophy to establish.

A

AERIAL (*Gk.*, aer, air; -al) adj. pertaining to the air, or to anything occurring in the air, or on the surface of the earth.
—**SUB-AERIAL**; (*L.*) below the air, or on the surface of the earth.

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- ral scientific term for those cellular aquatic plants familiarly known as "sea-weeds." Though mostly of marine habitat, many are of fresh-water growth, lacustrine, or fluvial.
- ALLUVIUM, ALLUVIAL** (Lat. *ad*, together, and *luere*, to wash).—Matter washed or brought together by the ordinary operations of water is said to be *alluvial*, and the soil or land so formed is spoken of as *alluvium*. The soil of most of our river-plains (dales, vales, holmes, and carses) is of alluvial formation; these low grounds having once been the sites of lakes, estuaries, and shallow arms of the sea.
- AMPHIGENIA** (Gr. *amphi*, all around, and *gignomi*, I am formed).—Plants which increase by the growth or development of their cellular tissue on all sides, as the lichens.
- ANADROMOUS** (Gr. *ana*, upwards, and *dromos*, a flight or running).—Applied to aquatic animals which, like the salmon and sturgeon, periodically forsake the waters of the ocean and ascend into fresh-water lakes and rivers for the purpose of spawning. Fishes are thus spoken of as *marine*, *fresh-water*, and *anadromous*, the two former never quitting their native elements, and incapable of subsisting in any other, and the latter possessing the power and habit above alluded to.
- ANALOGY** (Gr. *ana*, along with, and *logos*, reasoning).—That relationship, resemblance, or correspondence which one object bears to another in functional duty or performance.—**ANALOGUES**, the objects that bear such resemblance or relationship.
- ANCHORAGE or ANCHOR-GROUND**.—Any portion of a bay, estuary, channel, or arm of the sea, where the bottom is unimpeded by rocks, and the water of a suitable depth for ships riding at anchor.
- ANEMOMETER** (Gr. *anemos*, the wind; *metron*, a measure).—An instrument (of which there are several kinds) for determining the direction and measuring the velocity and force of the winds.
- ANEROID** (Gr.).—Literally, without fluid. In the *aneroid barometer* the pressure of the atmosphere is measured by the elevation or depression of the top of a closed metallic vessel exhausted of air. The pressure of the atmosphere being marked on a scale, any alteration is indicated by the movements of the surface of a thin corrugated metal, and communicated to wheels marking the pressure on a dial furnished with a pointer. Being easily carried about, the aneroid is extremely useful in enabling the traveller and tourist to approximate the relative heights of situations.
- ANTARCTIC** (Gr. *anti*, opposite, and *arctic*).—Applied to the regions surrounding the south pole, as being opposite to those of the *Arctic* or north pole, which see. Thus, we speak of "antarctic regions," "antarctic circle" (66½° south of the equator), and of situations "within the antarctic circle."
- ANTHRACITE** (Gr. *anthrax*, coal).—A species of coal almost wholly deprived of its bitumen, and which, therefore, burns without smoke or flame. It may be regarded as a natural coke or charcoal, formed from ordinary bituminous coal by subterranean or chemical heat. It occurs in most coal-fields, but largely, and on a most available scale, in the United States of America.
- ANTICLINAL** (Gr. *anti*, opposite, and *klino*, I bend).—Bending or sloping in opposite directions from a common ridge or axis, like the roof of a house. Such a ridge or axis is called, in geological language, an "anticline" or "saddle-back."
- ANTIPODES** (Gr. *anti*, opposite; *podos*, foot).—Applied to those who dwell on opposite sides of the globe, as having their feet diametrically opposed to each other. Those in New Zealand, for example (or rather Antipodes Island, near New Zealand), are the antipodes of those in Great Britain.
- ANTISEPTIC** (Gr. *anti*, opposed to; *sepsis*, I putrefy).—Substances which, like common salt and tannin, prevent putrefaction in animal and vegetable matter, are said to be *antiseptic*, or to possess *antiseptic properties*.
- APHELION** (Gr. *apo*, from; *helios*, the sun).—The point in a planet's orbit at which it is farthest from the sun; its *perihelion* being the point at which it is nearest.
- APOGEE** (Gr. *apo*, from; *ge*, the earth).—That point of the moon's orbit in which she is farthest from the earth; her *perigee* being the point in which she is nearest the earth.
- AQUATIC** (Lat. *aqua*, water).—Relating to the water; having its habitat or usual position in water. Applied to plants, like the water-lily, and to animals, like the water-snake, and the water-bug.

ARCHIPELAGO.—A term originally applied to the numerous islands that stud the Aegean Sea—the *Grecian Archipelago*; but now used to denote any similar cluster of islands—e.g., the Indian Archipelago, or East India Islands.

ARCTIC (Gr. *arktos*, a bear).—Relating to the north pole or polar regions; in reference to the constellations of the Great and Little Bears which occur in the northern quarter of the heavens, and point, as it were, to the north pole.—*Arctic Regions*, the high latitudes surrounding the north pole: *Arctic Circle*, an imaginary line extending round the north pole $66\frac{1}{2}^{\circ}$ from the equator and parallel to it; hence certain parts are said "to lie within the arctic circle."

ARCTIC CURRENT.—A well-known ocean current which originates in the polar regions of the north and flows southwards towards the equator. The main current seems to originate to the north of Spitzbergen, takes a westerly direction, and thence runs southward along the eastern shores of Greenland, till it meets with a minor branch flowing from Davis Straits. The two then unite into one great current, which follows the Labrador coast, runs to the east of Newfoundland, and evidently loses itself in the "Gulf Stream;" or rather, perhaps, from its greater density, passes in part under the Gulf Stream in latitude 45° — 47° , and holds on towards the equator.

ARGENTIFEROUS (Lat. *argentum*, silver; *fero*, I yield).—Applied to veins, rocks, and other matrices containing the ores of silver, or silver in the native or metallic state.

ARGILLACEOUS (Lat. *argilla*, clay).—Applied to all soils, rocks, or substances composed of clay, or having a notable proportion of clay in their composition.

ARM.—Any deep and comparatively narrow branch of the sea running inland, in contradistinction to gulfs and firths.

ARTESIAN WELLS.—Wells sunk by boring perpendicularly through the solid strata, and in which the subterranean waters rise to the surface, or nearly so—a method long known and practised in the province of Artois (the *Fontaine Artesienne* in France. Artesian wells are generally situated in or in basin-shaped valleys, in which the strata dip on one side, and their principle depends on the hydraulic principle of forcing water to the surface by the action of the atmosphere.

The greater the depth the higher the temperature of the water; and the lower the surface of the well compared with the outcrop of the water-yielding stratum, the higher will the jet of water rise above the orifice of the bore.

ASTEROIDS (Gr. *aster*, star; *eidos*, likeness).—A term applied by Herschel to the minor planets or *planetoids*—Ceres, Pallas, Juno, Vesta, &c.—of which there are now upwards of seventy known to astronomers.

ATMOMETER (Gr. *atmos*, vapour, and *metron*, measure).—An instrument invented by Sir John Leslie for measuring the amount of evaporation from any liquid or moist surface in a given time.

ATMOSPHERE (Gr. *atmos*, vapour; *sphaira*, sphere).—The gaseous envelope or volume of air which surrounds the earth on every side, and which is either directly or indirectly the cause of numerous geological and geographical operations, as well as the immediate medium of all climatic diversity—being the great laboratory in which all meteorological and electrical phenomena are elaborated, as winds, clouds, rains, snow, hail, and thunderstorms. As an air, it is composed of 79 parts nitrogen and 21 oxygen, with variable traces of carbonic acid and other impurities. Calculating from its decreasing density, as well as from its diminished power of refracting light, as we ascend from the earth, the height of the atmosphere has been estimated at 45 or 50 miles; and the pressure of the whole volume on every square inch of the earth's surface (at the ordinary sea-level) at 14.6 lb. avoirdupois.

ATOLL.—The name given to a coral island of an annular form—that is, consisting of a circular belt or strip of coral-reef more or less continuous, with an enclosed lagoon.

AURIFEROUS (Lat. *aurum*, gold; *fero*, I yield).—Yielding or containing gold; applied to veins, rocks, and rock-substances containing the precious metal, as "auriferous veins," "auriferous gravels," and the like.

AURORA BOREALIS (Lat.).—Literally the "Aurora of the North;" known also as the *Northern Lights*, *Polar Lights*, *Streamers*, &c. A luminous meteor, generally appearing in the northern heavens, and so called from its resemblance to the *aurora* or morning twilight. It is usually referred to electrical agency in the upper regions of the atmosphere. Changing from the purest and softest white to all the colours of the rainbow, and flickering and flitting from the horizon to the zenith with inconceivable rapid-

ity, the aurora borealis is one of the most attractive of celestial phenomena.

AUTUMN (Lat.)—The third quarter of the year which commences when the sun enters *Libra*, that is, about the 21st or 22d of September, when the days and nights are equal; hence the term *Autumnal Equinox* or *Autumnal Point*, referring to the descending point of the ecliptic.

AVAILANCHE (Fr. *avalanche*, *lawange*, *lavanche*).—An accumulation of snow, or of snow and ice, which descends from precipitous mountains like the Alps into the valleys below. Avalanches originate in the higher regions of mountains, and begin to descend when the gravity of their mass becomes too great for the slope on which it rests, or when fresh weather destroys its adhesion to the surface. They are usually distinguished as Drift, Rolling, Sliding, and Glacial;—

Drift are those caused by the action of the wind on the snow while loose and powdery; *Rolling*, when a detached piece of snow rolls down the steep, licks up the snow over which it passes, and thus acquires bulk and impetus as it descends; *Sliding*, when the mass loses its adhesion to the surface, and descends, carrying everything before it unable to resist its pressure; and *Glacial*, when masses of frozen snow and ice are loosened by the heat of summer and precipitated into the plains below.

AXIS (Lat. a pole or axletree).—A word used largely and variously in natural science; applied to the line about which objects are symmetrical, about which they are bent, around which they turn, or to which they have some common relation; hence "vertical axis;" "axis of elevation;" "axis of rotation;" "synclinal axis," &c.

B

BAROMETER (Gr. *baros*, weight; *metron*, measure).—A well-known instrument for measuring the weight or pressure of the atmosphere by balancing a column of air against a column of mercury; and by this test determining variations in the state of the air, foretelling changes in the weather, as dependent on the conditions of the air, and measuring heights and depths as indicated by the proportional pressure of the air.

BARRIER REEF.—The name given to those coral-reefs that run parallel (*barrier-like*) to the shores of islands and continents, but separated therefrom by a lagoon-channel more or less extensive. The barrier-reefs of Australia and of New Caledonia, owing to their enormous dimensions, have long excited the attention of voyagers.

BASIN.—Applied, in Geography, to the whole extent of valley-shaped or basin-shaped country drained by any river and its tributaries, as the "basin of the Thames," the "basin of the Forth," &c.

BATHYMETRICAL (Gr. *bathys*, deep, and *metron*, measure).—Applied to the distribution of plants and animals along the sea-bottom, according to the depth of the zone (measuring from the shore) which they inhabit.

BAY.—Any bending of the ocean on the land, less sudden and contracted than a creek or harbour, and communicating more openly with the main ocean than a sea or gulf; "1 of Biscay," "Bay of Bengal."

BEACH.—The shore of the sea; the

strand—strictly speaking, that space along the margin of a tidal sea over which the tide alternately flows and ebbs.

BIOLOGY (Gr. *bios*, life, and *logos*, doctrine).—The science of life, whether vegetable or animal, embracing botany and zoology in their widest acceptation. — **BIOLOGICAL**, relating to the science of life; life in all its multifarious manifestations and developments.

BISE.—A cold and cutting north-east wind which descends from the snow-covered Alps in spring and early summer; often ravaging the south of France.

BLANCHING (Fr. *blanche*, white).—The process of whitening the leaves and stems of plants by excluding the light, and thus preventing the development of their natural properties. — **BLANCHED**, whitened.

BLUFFS.—A term said to be of American origin, and used to designate high banks presenting a precipitous front to the sea or a river.

BOG (Celtic, *soft*).—The common designation for any wet, spongy morass, consisting chiefly of decayed vegetable matter.—**BOG**, *soft*, *decayed*, *vegetable*, *matter*.

duce variation are increased or diminished atmospheric pressure, the greater or less depth of the liquid, and the nature of the vessel in which it is contained. Thus, the boiling point of water under ordinary circumstances, at the level of the sea, is 212° Fahr.; but it will boil and bubble up at a much lower temperature on the top of a high mountain, in consequence of diminished pressure; it will also boil sooner and more quietly in a rough-surfaced vessel than in a smooth and polished one; and also more quickly in a shallow vessel, in consequence of the less resistance by the superincumbent water to the escape of steam. The boiling point is also raised considerably by saline admixture, so that pure water, which boils at 212°, requires 288° when fully saturated with salt. *In vacuo*, all liquids boil at a temperature 124° lower than in the open air, at the ordinary pressure of the atmosphere.

BORE.—A violent rush of tidal water; the advancing edge or front of the tidal wave as it ascends a river or estuary; *e.g.*, the Bore of the Hooghly, the Garonne, the Severn, the Tsientang, &c. The bore of the Tsientang is said to advance up that river at Hangchow like a wall of water, thirty feet in height, and at the rate of twenty-five

miles an hour, sweeping everything before it.

BOREAL (Lat. *Boreas*, the north wind).—Of or belonging to the north; *e.g.*, Boreal Regions, Boreal Fauna, &c.

BOTTLE-TRACK.—The name given to the course pursued by bottles which are thrown overboard with a note enclosed of the longitude and latitude where and the date when they are dropped in the ocean. By this means the set-in and velocity of currents are rudely indicated.

BOULDERS (Sax.).—Any rounded or water-worn blocks of stone, which would not, from their size, be regarded as pebbles or gravel, are termed *boulders*. The name, however, is usually restricted to the large water-worn and smoothed blocks ("erratic blocks") found imbedded in the clays and gravel of the Drift formation, which covers the northern hemisphere, in both worlds, down to the 40th or 42d parallel of latitude.

BOURRANS.—The name given to the fierce snow-storms that blow from the north-east over the steppes of Russia, and which often rage for twenty-four hours at a time.

BRISKE.—The general term for a wind of some briskness, but of limited extent and duration; less violent than a *gale*.

C

CAINOZOIC or CAENOZOIC (Gr. *kainos*, recent; *zoe*, life).—Applied to the upper stratified systems, as containing recent forms of life, in contradistinction to the *Mesozoic* (holding intermediate) and the *Paleozoic* (holding ancient and extinct forms). As a paleontological subdivision, the Cainozoic embraces the tertiary and post-tertiary formations.

CALCAREOUS (Lat. *calx*, *calcis*, lime).—Composed of or containing a considerable proportion of lime; *e.g.*, *calcareous soils*, *calcareous sandstones*, &c.

CALCARIFEROUS.—Literally, lime-yielding. A term occasionally applied to springs charged with carbonate of lime, and which on issuing into the air deposit incrustations of calcareous tufa. The "petrifying springs" of ordinary language.

CANAL.—A Spanish term for the deep don-like cavities that occur on the flanks of extinct volcanic mountain islands, and evidently the bed craters of ancient

dimensions. A tube less than the twentieth of an inch in diameter is capable of sustaining or attracting any liquid considerably above the level at which it is immersed; and this *capillary attraction*, as it is termed, is a phenomenon which occurs less or more in all porous bodies (soils, sandstones, &c.)—the minute interstices acting as capillary tubes, and "drawing" or "attracting" any liquid considerably above the level of its mass.

CARBONIFEROUS (Lat. *carbo*, coal; *fero*, I yield).—Coal-bearing, coal-yielding. The term is usually applied to that system of strata from which our main supplies of coal are obtained, or to the respective groups or members of that system; *e.g.*, "carboniferous system," "carboniferous limestone," &c.

CARDINAL (Lat. *cardo*, a hinge).—A term implying importance, and suggestive of the hinge or point on which a thing turns or depends. Thus the *cardinal points* of the compass are the North, East, and West; the *cardinal signs* of the zodiac, Aries, Cancer, and Capricorn.

CARNI (Lat. *caro*, *carnis*, flesh; *vero*,

(Lat. *capillus*,
applied to flammulae
of very fine

- I devour).—One of Cuvier's orders of the mammalia, embracing the lion, tiger, hyena, and others that subsist solely on flesh.—*CARNIVOROUS*, living on flesh, in contradistinction to *Herbivorous*, *Gramivorous*, &c.
- ✓ **CATACTYSM** (Gr.)—A sudden flood, deluge, or inundation. Generally applied to some abnormal or unusual effect of moving water.—**CATACTYSMAL**, belonging to, or produced by, the violent force of water.
- CHALYBEATE** (Gr. *chalybs*, iron or steel).—Applied to springs and waters impregnated with iron, or holding iron in solution.
- CLIMATE** (Gr. *klima*, an inclination).—Originally applied (as explained in the text), in a technical or astronomical sense, to the various belts of the earth as influenced by the heat of the sun; but now applied to the general weather-conditions of any district, as these may be mild or rigorous, genial or ungenial, salubrious or obnoxious. In treating of countries, geographers speak of *insular* and *continental* climates; the former, from its proximity to the ocean, being comparatively mild in winter and cool in summer, and the latter cold in winter, but excessively hot in summer.
- CORAL-REEF**.—The term applied to any connected mass of coral structures, whether trending away in long partially-submerged ledges, encircling islands like breakwater-barriers, or rising as low ring-shaped islets above the waters of the ocean. Such masses are found studding the Pacific on both sides of the equator to the thirtieth degree of latitude; abounding in the southern part of the Indian Ocean; trending for hundreds of miles along the north-east coast of Australia; and occurring less or more plentifully, in patches, in the Persian, Arabian, Red, and Mediterranean Seas. In the Pacific, where volcanic agency is actively upheaving and submerging, coral-reefs are found forming low circular islands, enclosing lagoons (*atolls* or *lagoon islands*); surrounding islands of igneous and other origin (*fringing* or *shore reefs*); crowning others already upheaved (*coral ledges*); or stretching along shore in surf-beaten ridges (*the true barrier or encircling reef*) of many leagues in length, and from 20 to more than 200 feet in thickness.
- COSEMIC** (Gr. *kosmos*).—Literally, order in natural order, like the arrangement of the universe. The word is used of the material or from the order of symmetry of its component parts.—**COSMICAL**, relating to the world or universe.—**COSMOLOGY**, the science which treats of the several parts of the world, their laws and relations.
- COULÈES** (Fr. *coulée*, to flow, as melted metal).—Applied to the *streams* and spurs of lava which diversify the sides and slopes of volcanic mountains.
- CRAQ AND TAIL**.—Applied to a form of hills common in Britain, where a bold precipitous front (the crag) is exposed to the west or north-west, and sloping declivity (the tail) towards the east. In general geographical terms, the *slope* and *counter-slope* of these hills. The phenomenon of crag and tail is evidently the result of the currents of the Drift epoch, which, in our latitudes, swept from north-west to north-east, laying bare the opposing heights, but leaving untouched the sheltered slopes and terraces.
- CRATER** (Gr. *krater*, a cup or bowl).—The mouth or orifice of a volcano: so called from its cup or bowl shape. Craters may be central or lateral in the mountain in which they occur; there may be one principal and several subsidiary ones; and they may shift their places and become absorbed by subsidence, or be obliterated by eruptions from more active orifices.
- CRATERIFORM**.—Applied to hills whose summits present bowl-shaped and other circular depressions that seem to have been the craters of once active volcanoes. We thus speak of the "crateriform hills of Auvergne"—hills which were undoubtedly in a state of igneous activity during the tertiary period.
- CUPRIFEROUS** (Lat. *cuprum*, copper, and *fero*, I yield).—Applied to veins, rocks, and other matrices containing the ores of copper, or copper in the native or metallic state.
- CYCLE** (Gr. *kuklos*, a circle).—A definite period of time, marked by the recurrence of the same natural phenomena.
- CYCLOSK** (Gr. *kuklos*, a circle).—A term applied by navigators to those rotatory hurricanes which occur most frequently between the equator and the tropics, and near the equatorial limit of the trade-winds. They sweep round and round with a progressive motion, their course describing a curve, and their violence being greater the narrower the limit of their whirl. In both hemispheres the rotation of a cyclone is such that the left of the sun; those in the northern hemisphere moving westward, and in the southern

D

DEBACLE (Fr. *debâcler*, to unbar).—A term originally signifying the breaking up of the ice on a river—a freshet; but now applied to any sudden flood or rush of water which breaks down opposing barriers, and hurls forward and disperses blocks of stone, gravel, and other debris.

DEBRIS (Fr., wreck or waste).—A convenient term, adopted from the French, for any accumulation of loose material arising from the waste of rocks: also for drifted accumulations of vegetable or animal matter.

DEGRADATION (Lat. *de*, down, and *gradus*, step).—Removing or wasting down step by step. The degradation of hills and cliffs is caused by atmospheric and aqueous agency; hence water is said to exert a *degrading* influence on the earth's crust; waves and tidal currents a *degrading* action on certain sea-shores.

DELTA.—The alluvial land formed at the mouth of a river such as that of the Nile, which received this name from the resemblance of the space enclosed by the two main branches of the river to the Greek letter Δ, *Delta*. The deltas of many large rivers, such as the Mississippi, Niger, Ganges, &c., present the inquirer with some of the most remarkable and instructive of geographical and geological phenomena.

DEPOSIT (Lat. *de*, down; *positus*, placed).—Applied to matter that has settled down from suspension in water. Deposits are either distinguished by their composition, as "mud-deposits," "sand-deposits," &c.; by the positions in which they occur; or by the agencies concerned in their formation, as fluvial, lacustrine, estuarine, marine, &c.

DETRITUS (Lat. *de*, down; *tritrus*, rubbed or worn).—An appropriate term for all accumulations arising from the waste or disintegration of exposed rock-surfaces, sea-cliffs, mountain-cliffs, river-banks, and the like. *Detrital* matter may thus consist of mud, sand, gravel, rubby fragments, or of any admixture of these.

DICOTYLEDONOUS (Gr. *dis*, double; *kotyledon*, seed-lobe).—A grand division of the vegetable kingdom, comprising all those plants whose seeds are composed of two lobes or seed-leaves. They are exogens, or increase by external layers of growth, and the venation of their leaves is reticulated or net-like, and not in parallel cotyledonous end

DIP.—The inclination

of a strata slope or dip downwards into the earth. This angle is measured, of course, from the plane of the horizon or level, and is easily ascertained by the common spirit-level and plummet. Some rocks dip at a low angle and are flat; others incline at a very high angle, and are almost on edge.

DOAB.—The name given in India to the tongue of land that lies between the confluence of two or more rivers, as the *doabs* of the Punjab, or plains that lie between the rivers of that region.

DOLDRUMS.—A sailor's term for the tropical zones of calms and variables—belts in which they are often detained for weeks by baffling calms, storms, and rains.

Downs (Brit. *dune*, a hillock).—Applied in the south of England to the rounded, dry, and unwooded chalk hills of Kent, Surrey, Sussex, and adjacent counties. These "downs" are described "as covered with a sweet, short herbage, forming excellent sheep-pasture, generally bare of trees, and singularly dry even in the valleys that wind for miles between them."

DRIFT.—Literally, "that which is driven;" as *sand-drift*, sand driven and accumulated by the wind; *drift-wood*, wood carried down by rivers and driven by tides and currents to distant shores. Such drift-wood is often useful in indicating to geographers the course and direction of oceanic currents.

DRIFT-CURRENTS.—The name given to oceanic currents which mainly depend on the winds. The monsoons which prevail in the Indian Ocean give rise to drift-currents, which set alternately in one direction and then in another, according to the season of these winds.

DROSOMETER (Gr. *dros*, dew; *metron*, measure).—Literally "dew-measurer;" any apparatus or instrument for determining the amount of dew deposited during a single night. "The most simple process," says Professor Kaemtz, "consists in exposing to the open air bodies whose exact weight is known, and then weighing them afresh after they are covered with dew. According to Dr Wells, locks of wool, weighing five decigrammes, are to be preferred, which are to be divided into spherulic masses, of the diameter of about five centimetres."

DUNE (Brit. a hill).—Usually applied to hillocks of blown sand. *Sand-dunes*, sand-drift like that which, in some places, skirts the low shores of our own island.

E

EARTH'S CRUST.—That external rind or shell of our planet which is accessible to human investigation; in contradistinction to the internal mass, of which we know nothing by direct observation.

EARTHQUAKE.—The familiar as well as scientific term for any sudden shaking of a portion of the earth's crust produced by subterranean agency. With its causes, that produce, and the consequences that accompany earthquakes, we are not generally acquainted; but we know that their results are fractures, fissures, and spasms in the earth's crust; upheavals and depressions; levations of the sea-bed into mountains; and the submergence of dry land beneath the waters of the ocean.

EARTH-SALT.—A water, and a back-water. —Any rotatory motion of water caused by the meeting of opposing currents. Whirls generally occur in squares where the tide meets the current of the river; and in seas where currents from different quarters meet, wherever these currents are brought into themselves by opposing obstacles.

EMBOUCHURE (Fr.)—The mouth of a river, or that part where it enters the sea.

ENDOGENS (Gr. *endon*, within; *nomai*, I am formed).—That division of the vegetable kingdom whose growth takes place from within, and not by external concentric layers as in the *Exogens*.

EQUATOR (Lat. *æquus*, equal).—The great circle on the earth's surface, every point of which is equally distant from the poles; such a circle cuts the globe into two equal parts or halves—in other words, into *hemispheres*, viz., the Northern and Southern. When the sun is in the line of the equator, day and night are of equal duration, hence it is also termed the *equinoctial line* (over, the night).—**EQUATORIAL**, belonging to, or in the region of, the equator.

EROSION (Lat. *erodis*, gnawed or worn away).—The act of gradually wearing away; the state of being gradually worn away, e.g., "Valleys of erosion," or those valleys which have been gradually cut out of the solid strata.

the long-continued action of the river or rivers that flow through them.

ERRATIC BLOCKS.—A term frequently applied to those large water-worn and ice-borne blocks of stone (*boulders*) which are scattered so generally over the higher and middle latitudes of the northern hemisphere.

ENCARPMENT (Fr. *scarper*, to cut steep).—The abrupt face or cliff of a ridge or hill-range.

ESTUARY (Lat. *æstus*—*æstuo*, I boil—the tide; so called from the troubled boiling-up of the water-line, which marks its approach in river-mouths).—Estuaries are, properly speaking, tidal river-mouths, like those of the Thames, Severn, Solway, &c., whose fauna and flora are mixed fresh-water and marine, or composed of such species as are peculiar to brackish waters.

EUROPEAN WIND (Gr. *ëtesias*, annual).—A northerly, or rather north-easterly wind that prevails very much in early summer all over Europe.

ETHNOGRAPHY (Gr. *ethnos*, a race; *graphe*, a description).—An account or description of the origin, dispersion, connection, and characteristics of the various races of mankind.

EVAPORATION (Lat. *evapero*, I send off in vapour).—The act of converting into vapour such liquids as water, either by natural or by artificial means, the former being termed "*spontaneous evaporation*." Heat is the grand evaporating agent in nature, and its effects are greatly facilitated by the removal of the vapour as soon as it is formed either by currents of wind, by absorption, or by other analogous means.

EXOGENS (Gr. *exo*, without; *ginomai*, I am formed).—That great division of the vegetable kingdom whose growth takes place by external concentric layers, and not from within as in the *Endogens*.

EXOTIC (Gr. *exon*, from without).—Applied to plants and animals, but chiefly to the former, that have been introduced into a country from other regions—that is, from without. Used in contradistinction to *indigenous*, or naturally belonging to a region, which see.

FACIES (Lat.)—A convenient word to express any circumstance or aspect among things.

as distinct from the floras of other epochs; and of the "facies of the Australian fauna" as distinguished from the animals of other regions by their common marsupial characteristics.

FAMILY.—In Natural History classifications this term denotes the group next in value and comprehensiveness above the *genus*. As species constitute a genus, so genera constitute a family.

FATA MORGANA.—The phenomenon of the *mirage* at sea. It arises from two currents of air of different density or temperature coming suddenly in contact; and as at sea the upper is generally the warmer and the lower the colder, the former becomes condensed at the place of contact, and forms, as it were, a mirror for the objects which are in the lower current, so that their images are inversely reflected. As the surface of separation is not level throughout, various refractions and distortions result, which often impart to the whole a singular and fantastic appearance. On land, where the warmer current of air is on the surface of the ground, the aerial mirror is formed beneath the eye of the observer, by which the same phenomenon is produced that results from the reflection of objects on the surface of the water. The name is said to be of Breton origin—*mor*, sea, and *gana*, fine lady—the fairy mermaid of our popular legends.—See *Mirage*.

FAUNA (Lat. rural deities).—A convenient term for the animals of any given epoch or area; e.g., the "fauna of South America," the "fauna of the Permian era." As the animals of an area or epoch constitute its **FAUNA**, so the plants constitute its **FLORA**.

FERRIFEROUS (Lat. *ferrum*, iron; *fero*, I yield).—Applied to veins, rocks, and other matrices that yield or contain iron.

FERRUGINOUS (Lat. *ferrum*, iron; *gino-mai*, I become).—Impregnated or coated with oxide of iron; rusty-looking.

FLORA (Lat. the goddess of flowers).—A convenient term for the vegetation of any given epoch or area—as "the flora of the coal-measures"—"the flora of South America." As the plants of a country or epoch constitute its **FLORA**, so the animals constitute its **FAUNA**.

FLUVIATILE (Lat. *fluvius*, a running water).—Belonging to a river; produced by river action; growing or living in fresh-water rivers.

UL (Lat. *fossilis*, dug up).—Literally, thing dug out of the earth; but restricted by geologists to "or-

ganic remains," or the remains of plants and animals imbedded in the earth's crust, and more or less altered in structure and composition by mechanical and chemical agencies. When these remains are only partially petrified, and occur in superficial or recent deposits, the term *sub-fossil* is employed.

FOSSILIFEROUS (Lat. *fossilis*, and *fero*, I bear).—Applied to rocks and rock-systems containing organic remains, in contradistinction to *non-fossiliferous*, or those which contain no such relics.

FRESHET.—A river flood or inundation occasioned by the sudden melting of the ice and snow in spring; the predominance of fresh water in tidal estuaries during periodical rain-falls and land-floods.

FRINGING-REEFS.—A class of coral-reefs, known also as "shore-reefs," from their fringing or encircling islands at a moderate distance from shore. "They differ from barrier reefs," says Darwin, "in not lying so far from shore, and in not having within a broad channel of deep water." The reefs which fringe the island of Mauritius form a good example of the class.—See *Coral Reef*.

FIRTH (Lat. *frctum*).—An arm of the sea, as the Frith of Forth, the Frith of Tay, &c. Originally applied to any strait narrow passage, or inlet.

FROST (Sax.).—In Meteorology, the freezing, or conversion into ice, of water and watery vapours by the influence of cold. In ordinary circumstances water passes into ice when the temperature of the air falls to 32° of Fahrenheit; but as the cold increases the frost becomes more intense, and substances (such as oils, mercury, &c.) which remained liquid at 32°, gradually lose their caloric and pass into the solid state. As a geological agent, frost exerts a purely mechanical influence, but this influence is of prime importance in disintegrating rocks and soils, moulding the outline of mountains, and assisting in the dispersion of boulders and other debris, not only from higher to lower levels, but from the land over the bottom of the ocean. The *avalanche*, *glacier*, and *iceberg*, among the most notable of geographical phenomena, are the children of the frost, cradled on the snowy summits of lofty mountains, or in the icy seas of the polar regions.

FUMEROLE (Ital. *fumare*, to smoke).—An opening or orifice in a volcanic district from which eruptions of smoke and other gaseous fumes are emitted.

G

GARUA.—The local term for dense sea-fogs that occur periodically along the Pacific coast of South America. During the Garua, it is said, the atmosphere loses its transparency, and the sun is obscured for months together. The vapours of the garua of Lima are so thick that the sun, seen through them with the naked eye, assumes the appearance of the moon's disc. They commence in the morning, and extend over the plains in the form of refreshing fogs, which disappear soon after mid-day, and are followed by heavy dews, which are precipitated during the night.

GENUS (Lat. kind or kindred).—In Natural History the word *genus* is generally used to embrace such members of a family or larger group as possess some common properties, more marked in them than in the other members of the family. Thus the *CANIDÆ* or Dog-family embraces the dog, wolf, jackal, fox, &c.; but the dog, wolf, and jackal are regarded as one genus, *canis*, while the foxes are separated into another genus, *vulpes*, the points of agreement between the dog and wolf being more numerous and intimate than between the dog and fox.

GEOLOGY (Gr. *ge*, the earth, and *logos*, doctrine).—Embraces all that can be known of the constitution and history of our planet. Its object is to examine the various rock-materials of which our planet is composed, to describe their appearance and relative positions, to investigate their nature and mode of formation, and generally to discover the laws which seem to regulate their arrangement. In this respect it differs from *Geography*, which

restricts itself more especially to the external or superficial aspects of the globe, and the life that adorns it.

GEYSER.—Literally "rager;" an Icelandic term for the intermittent boiling springs or spouting fountains which occur in connection with the volcanic phenomena of that island. The term has reference to the violent discharges of steam and water which take place at stated intervals, the jets being thrown with explosive force to a great height in the air.

GHAUTS.—A term applied originally to the narrow and difficult passes in the mountains of Southern India, but has been gradually extended to the mountains themselves—viz., the Eastern and Western Ghauts, which consist of two great chains, stretching along the east and west coasts of the Deccan.

GLACIER (Lat. *glacies*, ice).—Applied to those accumulations of ice, or of snow and ice, which collect in the valleys and ravines of snowy mountains like the Alps, and which move downward (partly by their own gravity, and partly by the expansion of the water that falls into their crevices and fissures), with a peculiar creeping motion, smoothing the rocks over which they pass, and leaving mounds of debris (*moraines*), lateral and terminal, as they melt away.

GLACIER-TABLE.—The name given in Alpine regions to large table-like blocks of stone lying on the surface of glaciers, and more or less elevated on pedestals of ice—these pedestals being protected from the sun's rays by the superincumbent stone blocks, while the surrounding ice has been melted down to a lower level.

H

HABITAT.—The region occupied by any particular animal is called its *habitat*, and that of any particular plant its *station*—each being the locality which presents the conditions most favourable to its growth and development.

HAIL.—Frozen rain; rain-drops that have been suddenly frozen in their downward course by passing through a stratum of air below the temperature of 32°. Hail pellets are of various forms—round, angular, or flat—and often of considerable size.

HEADLAND.—Any prominent projection of the land into the sea; usually ap-

plied to a *cape*, *ness*, or *promontory* of some boldness and elevation.

HERRACEOUS.—Applied in Botany to stems that die down annually, in contradistinction to *lignous* or woody, persistent stems.

HERBIVOROUS.—(Lat. *herba*, herb, and *vor*, I devour).—Herb-eating; subsisting on vegetable food; in contradistinction to *carnivorous*.

HERVIDERO (Span. *hervir*, to boil).—The name given in Central America to the mud-volcanoes which occur in that and the contiguous districts of Mexico. The *hervideros* consist of mounds more

or less conical, with a crater at top, in which a clayey, fetid mud, of various colours and consistency, is kept in continual ebullition, and which is occasionally thrown up in pasty flakes that fall around, and form the conical mounds in question.

HOMOTEROIC (Gr. *homoteroic*, the same, and *zoë*, life).—Zones or belts of the ocean which, being under nearly the same circumstances as to climate, and consequently peopled in their different parts either by the same or representative species of animals, are said to be *homoteroic*, or marked by the same life.

HORNROS or **HORNOS**.—Literally *ovens*; a Spanish term for the low oven-shaped mounds or hillocks so frequent in the volcanic districts of South America, and from whose sides and summits columns of hot smoke and other va-

pours are usually emitted. They are only a few feet in height (five to ten), and, according to Humboldt, are not *eruptive cones*, but mere intumescences on the fields and sides of the larger volcanoes.

HUMMOCK (Sax., a knoll or mound).—Applied by sailors to blocks and masses of ice which have been frozen together so as to produce a rugged and uneven surface of the general ice-field.

HYGROMETER (Gr. *hygro*, moist; *metron*, measure).—An instrument for determining the humidity of the atmosphere. There are various kinds of hygrometers—some depending upon the principle of absorption of moisture, others upon the contraction of absorptive materials, and some, again, upon the principle of condensation upon cold polished surfaces.

I

ICEBERG (Ger. *eis*, ice, and *berg*, mountain).—The name given to the mountainous masses of ice often found floating in the polar seas. Sometimes they are formed by the accumulation of ice and snow; at other times they seem to have been originally glaciers launched from precipitous coasts into the ocean, and there further augmented by numbers of them freezing *en masse*. Icebergs have been seen in the Arctic and Antarctic Oceans several miles in circumference, rising from 40 to 200 feet above the water, and loaded with blocks of rock and masses of shingle. Some idea of their size may be formed from the fact that little more than an eighth of their bulk rises above the surface. As they are floated by the polar currents to warmer latitudes they melt away, dropping their burdens of boulder and rock-debris on the bottom of the ocean.

ICE-FLOW (Dan. ice-land).—Applied by voyagers to the smaller masses of ice that encumber the polar seas.

INDIGENOUS (Lat. native).—Applied to the plants and animals that naturally belong to a country or region. Not *exotic*, or introduced by artificial means.

ISLANDS (Lat. *insula*) occur either singly, when they are said to be *independent*; or in groups or clusters, when they constitute *archipelagoes*. They are also distinguished as continental and pelagic—continental when their proximity, geological character, and axial connection show them to be depen-

dencies of the continent; and *pelagic* when far off in the ocean they rise up independently, and are generally of volcanic or coralline formation.

ISOCHEIMAL or **ISOTHERMAL** (Gr. *isos*, and *cheima*, winter).—Having the same winter temperature; hence *isothermic lines* are those drawn through such places as have the same mean winter temperature.

ISOTHERMAL (Gr. *isos*, *ge*, the earth, and *therme*, heat).—Applied to lines or divisions in the earth's crust which have the same mean annual temperature, and employed as being more definite than *isothermal*, inasmuch as it refers solely to the land, whereas *isothermal* applies equally to air, land, and water.

ISOTHERMAL (Gr. *isos*, and *theros*, summer).—Having the same summer temperature; *isothermal lines*, lines connecting all those places on the surface of the globe which have the same mean summer temperature.

ISOTHERMAL (Gr. *isos*, and *therme*, heat).—Having the same temperature equal temperature. In Physical geography, *isothermal lines* are lines connecting all those places on the surface of the globe which have the same temperature; and as temperature is governed by relative distribution of land and water, by altitude and conditions, places on the same parallel of latitude are often on very different isothermal lines.

- rations, deposits, life, and other features which occur near the shore, in contradistinction to those of a deep-water or *pelagic* character.
- LITTORAL ZONE** (Lat. *littus*, the shore).—That zone of marine life which lies between high and low water mark (varying in extent according to the rise and fall of the tide, and the shallowness of the shore), and which in British seas is characterised, as the bottom may be rocky, sandy, or muddy, by such mollusca as the periwinkle, limpet, mussel, cockle, razor-shell, &c., and by such plants as the bladder-wrack, ulva, and cariceen.—See *Zone*.
- LLANOS** (Span.).—The flat treeless plains that extend along the banks of the Orinoco. They are, for the most

part, within the tropics, and during one half of the year are covered with grass, and for the rest desolate. They are of very recent alluvial growth, and large areas being inundated during the rainy season, they are partly still in progress of formation.

LONGITUDE (Lat. *longitudo*, length).—The distance of a place measured in degrees, minutes, and seconds, east or west of any fixed meridian. In Britain, the fixed meridian is that of the Observatory of Greenwich; and in other countries it is usually that of their capitals. If the place be east of the fixed meridian, it is said to be in E. Long., and if west, in W. Long.—See *Latitude*.

M

- MAREMME** (Lat. *mare*, the sea).—The Italian term for those unwholesome sea-marshes that diffuse with more or less virulence their pestilential exhalations along the whole west coast of Italy.—See *Fontine Marshes*.
- MESOZOIC** (Gr. *mesos*, middle, and *zoe*, life).—The great division of stratified groups holding the middle forms of life, as differing from the Palæozoic and Cainozoic.
- METEORIC** (Gr. *meteoros*, raised above the earth).—Of or belonging to the atmosphere; and used as synonymous with *atmospheric*.
- METEORIC STONES or METEORITES** (Gr. *meteoros*, floating in the air).—See *Aërolite*.
- METROPOLIS**.—A term frequently employed by naturalists when treating of the geographical distribution of plants and animals. "Generic assemblages of plants and animals," says Edward Forbes, "whether terrestrial or aquatic, whether fresh-water or marine, have their regions, or definite geographical areas: these are what are known as 'generic areas.' Each of these has its *metropolis* or district of greatest numbers, either of typical or specific forms: geographical unity seems to be one of the essentials of every generic group."
- MILE**.—A well-known unit of measure, of which there are two kinds.—1. The *Geographical or Nautical mile*, 60 of which are equal to one degree of latitude; and 2. The *common or statute mile*, 66 of which are equal to one degree. The geographical mile is about 6079 English feet; the statute mile 5280 feet.
- MISÈRE** (Fr.).—A meteorological phenomenon occurring most frequently on 1 tract and 2

and occasioned partly by the unequal rarefaction of the vapour of the atmosphere, and partly by the intermixture of strata of air having different temperatures and densities. It assumes the appearance of a lake-like sheet of water, often exhibiting the reflected or inverted images of distant objects.—See *Fata Morgana*.

MIST.—The term applied to atmospheric vapour when it becomes visible in consequence of a reduction of the temperature of the air. *Mists, fogs, haws*, and the like, are common phenomena in insular and estuary-intersected countries like Great Britain and Ireland.

MOLLUSCA, MOLLUSCA (Lat. *mollis*, soft).—One of Cuvier's grand divisions of the animal kingdom, including all the "shell-fish" proper, and having reference to the circumstance that these creatures have *soft* bodies, unsupported by any internal or tegumentary framework of sufficient density to merit the name of skeleton.

MONOCOTYLEDONOUS (Gr. *monos*, one, and *kotyledon*, seed-lobe).—Plants whose fruit has only one seed-lobe, and consequently *endogenous* in growth, like palms, lilies, grasses, &c.

MONSOONS (Arab. *monsoun*, season).—The periodical or seasonal winds of the Indian Ocean—the south-west monsoon blowing, in general terms, from April to October; and the north-east, from October to April. The alternate heating and cooling of the African and Asiatic continents during the southern and northern summers are the prime producers of these periodical air-currents.

MORAINES.—The name given in Switzerland to the longitudinal mounds of stony detritus which occur at the

bases and along the edges of all the great glaciers. The formation of these accumulations is thus explained by Professor Agassiz.—The glaciers, it is well known, are continually moving downwards, in consequence, probably, of the introduction of water into their fissures, which, in freezing, expands the ice; and the ice being thus loosened or detached from the rocks on which it rests, is gradually pressed forward by its own weight. In consequence of this motion, the gravel and fragments of rocks, which fall upon the glaciers from the sides of the adjacent mountains, are accumulated in longitudinal ridges or moraines as the glacier melts away. These moraines are termed "lateral" when they occur in long narrow spits along the sides of the glacier; "terminal" when in transverse mounds at the lower end; and "medial" when

they occupy, in one long range, the middle of a valley that has once been filled by a glacier.

MOUNTAIN (Lat. *mons*).—Any portion of the earth's crust rising considerably above the surrounding surface. The term is usually applied to heights of more than 2000 feet, all beneath that amount being regarded as *hills*, and when of inconsiderable height, as *hills*. A *Mountain-Chain* or *mountain-range* is a series of elevations having their bases in contact, and their axes continuous over a considerable extent of country; and several ranges possessing a certain degree of parallelism, and evidently dependent on the same series of elevatory forces, constitute a *Mountain-System*.

MOYA (Span.).—A term applied in South America to the fetid sulphurous mud discharged by certain volcanoes.

N

NADIR (Arabic, down).—As the *zenith* is that point of the heavens directly above the head of a spectator, so the *nadir* is that point diametrically opposite, or vertically beneath his feet. In other words, they are the opposite poles of the visible horizon.

NASS, NASS, or NAZE, literally nose.—Any promontory or sudden projection of the land into the sea; as Dungeness, Fifeness, the "Naze," &c.

NODUS (Lat. *nodus*, a knot).—In Astronomy, the points where the orbit of a planet cuts the plane of the ecliptic; or generally, the points where the orbit of one planet cuts or crosses the orbit of another.

NORMAL (Lat. *norma*, a rule).—According to rule or law; obeying what is believed to be the natural law; occurring in the ordinary course of nature.

NULLAH.—A Hindostanee term for those streams, or rather stream-courses, which are mountain-torrents during the rainy season, and during the rest of the year are dry gravelly channels, with here and there a trickling of water.

O

OASIS (Egypt. *Awasis*).—In Physical Geography, a green and fertile spot in a desert; adopted from the Egyptian by Herodotus, and applied to the patches of vegetation which occur around springs in the Libyan desert.

ORBIT (Lat. *orbis*, a track or path).—The course or path of a planet round the sun; generally, the course or path described by any of the heavenly bodies. The term is derived from the Latin word *orbis*, a globe or circle; hence the heavenly bodies are spoken of as *orbs*, and their courses as *orbits*, though, strictly speaking, their form is merely spherical, and their courses elliptical.

OROGRAPHY, OROLOGY (Gr. *oros*, a mountain).—The science which describes or treats of the mountains and mountain-systems of the globe.

OS or OSEAR.—A Swedish term for those elongated hillocks or mounds of gravel belonging to the Drift or Glacial period, and which are at undantly and characteristically scattered over Sweden and the islands of the Baltic. The greater part of the gravel of these hills, which sometimes rise to 100 or 200 feet, consists of boulders, and they almost always have a source being to some source

P

PALÆOZOIC (Gr. *palaios*, ancient, and *zoe*, life).—The lowest division of stratified groups as holding the most ancient forms of life, in contradistinction to the *mesozoic* and *cainozoic*.

PAMPAS.—The vast treeless plains of the Paraguay and La Plata in South America, stretching from the eastern ridge of the Andes to the shores of Buenos Ayres, and thence southwards into the deserts of Patagonia. Though treeless, they are covered with luxuriant herbage—tall grasses and thistles—and are pastured by vast herds of wild cattle and horses.

PAMPERO.—The name given in Buenos Ayres to a violent west wind, which, traversing the arid plains of the Pampas, raises whirl-clouds of dust, and carries them forward to the coast of the Atlantic. The pamperos seem to be portions of the return, or north-western trade-winds.

PARAMOS (Span.).—The name given by the Spanish settlers to the high desert tracts of the Andes in South America.

PELAGIC (Gr. *pelagos*, the deep sea).—Of or belonging to the deep sea, as distinct from littoral or estuarine.

PERIGEE (Gr. *péri*, around, about, and *gē*, the earth).—That point of a planet's orbit at which it is nearest to the earth; its *apogee* being the point at which it is farthest off.

PLATEAU (Fr.).—Literally, a platform; introduced by the French geographer Buache, and applied to any elevated and comparatively flat surface of land; a *table-land* or high level region.

PLUVIOMETER (Lat. *pluvius*, rain; *metron*, a measure).—An instrument for catching falling rain, so as to determine the amount that falls at any given locality within a given period; a rain-gauge, of which there are several varieties in use by meteorologists.

POLDERS (Dutch).—The name given in Holland to the low fertile lands reclaimed by vast systems of dykes and embankments from the sea. The soil of the *polders* consists of muddy deposits, mixed with comminuted shells and fine sea sand; in other words, it is a fine marine silt, rendered fertile by the abundance of its organic debris.

POLAR (Gr. *polos*, I turn).—The extremes of the axis or imaginary line about which the earth turns in her rotation. They are respectively

the North and South, or the *Arctic* and *Antarctic Poles*; and the districts therewith connected are known as the *Polar Regions*. By prolonging the earth's axis towards the apparent celestial concavity in which the earth rotates, we form, in like manner, the *Poles of the Heavens*, north and south; and hence the *Pole* or *Polar Star*, from its proximity to the pole of the heavenly vault.

PONTINE MARSHES.—These sea-fens, so well known and dreaded by the inhabitants of Rome and the delta of the Tiber, are occasioned, according to Admiral Smyth, by the quantity of water carried into the plain by innumerable streams that rise at the foot of the mountains to the east of Rome, which, for want of sufficient declivity, creep sluggishly over the level space, and sometimes stagnate in pools, or lose themselves in the sands. Here, fermenting with decayed vegetable matter, and acted on by a fervid climate, malaria is produced—that invisible enemy that poisons the fairest portions of Italy, otherwise so salubrious, and renders man a sufferer from his cradle to his early grave. There is every appearance that the basin of these marshes was once a gulf of the sea, which has been gradually filled up by alluvium from the mountains.—See *Maremma*.

PORTAGE (Fr.).—Applied by voyageurs to the space or watershed that lies between the navigable branches of rivers belonging to the same or different hydrographic basins, and so called from the circumstance that boats and goods have to be carried from the one branch to the other. The name is also given to those parts where, in order to avoid cataracts or dangerous rapids, the boats are unloaded, taken out of the water, carried above the obstruction, and again launched and loaded.

PRAIRIES.—The open, slightly undulating, and grassy plains of North America. Situated in the Great Central Plain, the prairies are of vast extent; some are rolling, others are flat, and level in surface; many of them are treeless, and covered only with luxuriant grass and flowers; towards the south some tracts verge into a shrubby woodland, while in the extreme north the soil is largely swampy and desert.

R

RAIN-GAUGE.—An instrument, of which there are several kinds, for ascertaining the amount of rain-fall in any given locality.

RAVINE (Lat. *ruvis*, I sound hoarsely). A deep precipitous gorge, usually the narrow excavated channel of some mountain stream, and so called from the hollow murmur of its waters.

RECENT (Lat. *recens*, fresh, still growing).—In geological classification the term *Recent* is applied to all accumulations and deposits which have taken place during the human epoch, or are still in progress of formation. All accumulations and deposits whose fossil remains belong exclusively to species still existing, are, geologically speaking, "recent," though chronologically of vast antiquity.

REEF (Sax.)—A riff or ridge, usually applied to a range or ledge of rocks occurring in the sea, and only partially covered, or placed at no great depth under the surface of the water; e.g., the "coral-reefs" of the Southern Ocean.

REGION.—A term often loosely applied in geography, but applicable to any large tract of sea or land which is characterised by some feature not to be found in other areas.

RÉGION.—The native name for the cotton soil of India, which is said to cover nearly a third part of the southern peninsula, and to range northward to a great distance, and also into the Birman Empire. It occupies level plains; is of a bluish-black greenish-grey colour—from three to twenty feet in thickness; is of marvellous fertility, and evidently of alluvial origin.

RIVER (Lat. *rivus*, Gr. *ros*, I flow). The usual name for all considerable bodies of running water that traverse the land—*streams*, *runnels*, *rials*, and the like, being the terms for minor flows that feed the main river current. *River-basin*, the whole tract of valley-shaped or basin-shaped country drained by any river and tributaries; e.g., the "basin of the Severn," the "basin of the Tay." *River-plain*, any comparatively level and extensive tract traversed by or more rivers, and apparently the most part of alluvial origin.

ROADSTEAD OR ROADS.—Usually applied to an open and exposed anchorage where ships may ride under the shelter of the land, but from which they must sail when the wind is to blow strong from the sea.

S

SALINE (Lat. *sal*, salt).—Impregnated with salt, as "saline springs." *Saliferous*, containing or yielding salt, like the "saliferous strata" of Cheshire, in England.

SALISER.—Eruptions of hot acidulated mud from small orifices, generally in volcanic districts, and often accompanied by steam and gases at a high temperature, which act powerfully on the surrounding solid matters, disintegrating and decomposing them, and forming new compounds.

SAVANNAH OR SAVANNA (Fr.)—An American term for any vast grassy plain or prairie; but usually applied to the great central plain of North America, which may be said to stretch, with little perceptible interruption, from the Gulf of Mexico to the Arctic Ocean.

SCAR OR SCATH (Sax. *scra*, a piece of rock, like a scarp of north-west)

SCARPED (Fr. *escarpé*)
Having a steep ascent as to

toes front like many cliffs and mountains. Hence the term *scarp counter-scarp*, or *slope and counter-slope*, which see.

SCORLIE (Ital. *scorid*, dross).—Applied to all accumulations of dust, cinders, and other loose fragments of rocks discharged from active volcanoes, and often presenting mountain-sides of barren, cinder surface.

SCORIFORM.—In the form of, or resembling scorie. Applied to loose dery aggregations, occurring in igneous districts, and evidently of volcanic origin.

SILT.—This term is properly applied to the fine impalpable mud which settles in lakes and estuaries, and is generally designated all

- gions of the great Amazonian plain. Low-lying, damp, fertile in soil, and under the influences of a tropical sun, these *savannas* present the rankest luxuriance of primeval forest-growth.
- SIROOCCO.**—An Arabic term signifying *poison*, and applied to a hot suffocating wind, which occurs in most countries bordering on sandy deserts. Coming from the arid desert, and laden with the minutest particles, it often gives a red or reddish-dun colour to the atmosphere, and thus forewarns the traveller to take shelter from the approach of its pestilential breath. In Turkey it is called the *Samiel*; in Egypt *Khamia* (fifty), because it usually continues fifty days; and on the western coast of Africa, *Harmattan*.
- SIROCCO** (Arab.)—The name given to the hot parching wind which occasionally passes over Sicily and adjacent districts, and which is supposed to originate in the Sahara or Great Burning Desert of Africa.
- SLOPE and COUNTER-SLOPE.**—The majority of mountain-chains present on one side a long and gentle slope, and on the other a short and rapid one—the former is termed the *slope*, the latter the counter-slope. Thus the slope of the Andes is towards the Atlantic, the counter-slope towards the Pacific.
- SNOW-BLANKET.**—The name given by farmers and others to any considerable thickness of snow which covers the ground during winter, and helps to protect its vegetation from the severity of the frost. In continental countries, like central and northern Europe, this *blanket* is of essential service during severe and long-continued frosts in early spring.
- SNOW-LEIST or SNOW-BLINK.**—The name given by voyagers and travellers in the arctic regions to the peculiar reflection that arises from fields of ice or snow. An experienced seaman, it is said, can readily distinguish by the *blink* whether the ice is newly-formed, heavy, compact, or open. The *blink* or snow-light of field-ice is the most lucid, and is tinged with yellow; of packed ice it is pure white; ice newly formed has a greyish blink, and a deep yellow tint indicates snow on land.
- SNOW-LINE.**—That line or limit of elevation at which the air permanently attains the temperature of freezing water, and at and above which the surface is perpetually covered with snow and ice. The snow-line is, of course, highest towards the equator, and gradually descends as we approach either pole.
- SOLANO.** (Lat. *sol*, the sun).—A hot south-west wind which occasionally visits the Spanish peninsula, and, blowing from the direction of the African deserts, is regarded as a modified *sirocco*, which sea.
- SOLFATARA** (Ital. *solfo*, sulphur).—A volcanic fissure or other orifice from which sulphureous vapours, hot mud, and steam are emitted; akin to the *fumeroles*, *hornitos*, *hervideros*, and *salses* that occur in most volcanic areas.
- SOLSTICES** (Lat. *sol*, the sun; *sto*, I stand).—The two extreme points of the sun's apparent course north and south of the equator, and where he appears to make a stand, going neither northward nor southward. These are the first points of Cancer and of Capricorn, and the two corresponding seasons of the year are known as the *Summer* and *Winter Solstices*.
- SPOONDRIFT.**—During storms at sea, the violence of the tempest is sometimes so intense as to quell the billows, and scatter the water in a heavy shower, called by the sailors *spoon-drift*. On such occasions saline particles have impregnated the air to the distance of fifty miles inland.
- STATION.**—The region occupied by any particular plant is called its *station*, and that of any particular animal its *habitat*—each being the locality which presents the conditions most favourable to its growth and development.
- STEPPE.**—A Tartar term, adopted by geographers for those extensive flats or plains which occupy so large a portion of Northern Asia and Siberia. They are generally covered with long rough grass, are but partially wooded, and consist of alluvial deposits (sand, gravel, black-earth, bog-earth, &c.), all of comparatively recent formation.
- STUFA.**—An Icelandic term for those fissures or orifices in volcanic districts (like Heccla), from which jets of steam issue, often at a temperature much above the boiling-point of water.
- SUB-AERIAL.**—Literally "under the air;" applied to phenomena which take place on the earth's surface or under the open air, in contradistinction to *sub-aqueous*, or under the water.
- SUB-AQUEOUS** (Lat. *sub*, under; *agua*, water).—Applied to phenomena that take place in or under the water, in contradistinction to *sub-aerial*, or those that take place under the open air.
- SUBMARINE** (Lat. *sub*, under, and *mare*, the sea).—Under the sea: applied to objects that have their place at some depth in the waters of the sea, at the bottom of the ocean, or covered by the waters of the ocean; as "sub-

marine forests," "submarine volcanoes," and other analogous phenomena.

SUBMERGENCE (Lat. *submergo*, I plunge under water).—Applied to all sinkings of the land whereby its surface is brought under the waters of the ocean. Thus we have "submerged forests," "submerged islands," and so forth.

SUBSIDENCE (Lat. *sub*, under, and *sido*, I sink or settle down).—The act of sinking or settling down to a lower level. Applied in Geology to sinkings of portions of the earth's crust, which

may be either gradual and scarcely perceptible over a long lapse of years, or sudden and destructive as arising from earthquake convulsions.

SURF.—The name given to the "broken water" of waves that roll and break on comparatively flat shores. The surf along certain shores in the southern hemisphere is often very violent and almost incessant.

SYSTEM (Gr. *syn*, together, and *hístemi*, to stand).—Groups of objects or occurrences having such relations as permit them to be classed together, constitute a system.

T

TABLE-LAND.—Any flat or comparatively level tract of land considerably elevated above the general surface of a country. While *plains* and *valleys* are low-lying expanses but little broken by elevations and depressions, *tablelands* and *plateaux* are similar tracts, often of great altitude; e. g., the tableland of Central Spain, 2300 feet; and that of Mexico, 6000 feet above the level of the ocean.

TALUS.—The loose detritus accumulated at the base of cliffs and precipices, and derived from their weathered and wasted surfaces. Where the cliffs are high, and the rocks of a wasting nature, the talus in the course of ages assumes gigantic dimensions, and its long sloping surface becomes a characteristic feature in the landscape.

TERRACE.—Any shelf or bank of land having a uniformly flat or level surface. Such terraces are produced by the operations of water, and are either ancient sea-margins (*raised beaches*), or *lake* and *river terraces*; and point to a time when the valleys in which they occur were either occupied by lakes at these heights, or had their whole surfaces at these levels, and before their rivers had worn their channels down to lower depths.

THERMAL (Gr. *therme*, heat).—Applied to hot springs and other waters whose temperature exceeds that of 60° Fahr.

TIDES.—The name given to those regular oscillations, or risings and fallings of the water of the ocean, which are occasioned by the attraction of the moon and sun, and which occur twice in the course of the lunar day (24 hours 50 minutes). The flow, or rising towards the shore, is called *lood* tide, and the falling away *ebb* tide. The highest point to which the flood tide attains is called *high-water*, and the lowest to which the ebb tide sinks is called *low-water*. During *high* low

water there is a short period of rest, or no current either way, and this is called *slack-water*. When the sun and moon act in the same direction (that is, at full moon), the greatest tidal-rise will take place, and these are known as *spring-tides*: but when these luminaries are in opposition (that is, during the third and first quarters of the moon), the rise is least, and then we have *neap-tides*.

TOPOGRAPHY (Gr. *topos*, a place, and *graphe*, I describe).—A particular account of any locality, city, town, or village; in contradistinction to the general *geography* of the country in which it is situated.

TORNADO (Span. *tornado*, to turn).—A whirlwind; any violent storm or hurricane of wind, usually accompanied with thunder, lightning, and rain. Tornadoes, though excessively violent and destructive, are for the most part limited in area and of short duration.

TORRID ZONE (Lat. *torridus*, burning, scorching).—The middle zone or belt of the earth's surface, extending on each side the equator to the tropics of Cancer and Capricorn respectively; and so called from its high temperature.—See *Zone*.

TREMBORES.—The name given by the Spanish settlers of South America to the *surface-tremors* which, in some volcanic districts, are almost of daily occurrence.

TRIBUTARY.—Applied to any stream which directly or indirectly, contributes to another stream. Thus the *Amazon* is a direct tributary to the *Orinoco*, and the *Orinoco* is an indirect tributary to the *Amazon*. The *Orinoco* is a direct tributary to the *Amazon*, and the *Amazon* is an indirect tributary to the *Orinoco*. The *Orinoco* is a direct tributary to the *Amazon*, and the *Amazon* is an indirect tributary to the *Orinoco*. The *Orinoco* is a direct tributary to the *Amazon*, and the *Amazon* is an indirect tributary to the *Orinoco*.

sun seems directly to pass when he is at the greatest distance from the equator—viz., $23\frac{1}{2}$ degrees, and so called because he *turns* alternately southward and northward on reaching these points in his apparent annual course or ecliptic. The extreme divergence of the ecliptic from the equator being marked by the constellations Cancer and Capricorn, the one circle is called the northern tropic or Tropic of Cancer, and the other the southern, or Tropic of Capricorn. The zone or belt of the earth within these circles is said to

be "within the tropics" or "*tropical*," and constitutes the Torrid Zone of climatologists. Plants, animals, climate, and other phenomena occurring within this region are said to be *Tropical*; those on the extreme temperate verges of the region, *Sub-tropical*.

TYPHOON (Gr.).—Literally, a tempest or whirlwind. *Typhoons*, the name given by navigators to the hurricanes that visit, generally from June to November, the seas of Southern China, and the adjacent archipelago of the Philippines and Moluccas.

V

VALLEY (Lat. *vallis*).—Any depressed or low-lying tract of land bounded by hill or mountain ranges; and usually traversed by a stream or river which receives the drainage of the surrounding heights. We have thus "circular valleys," "longitudinal valleys," and "cross valleys," according to the configuration and disposition of the bounding heights; though, generally speaking, longitudinal valleys, taking their names from the rivers which flow through them, are the most characteristic and common. A level tract of great extent, and traversed by more rivers than one, is, properly speaking, not a valley, but a *plain*; and deep narrow river-courses, on the other hand, are more correctly designated *glens*, *ravines*, and *gorges*.

VARIABLES.—Near the equator the trade-winds, north and south of it for a certain distance, completely neutralise each other, and the zone of calms and

light breezes so formed is known as the *Variables*.

VOLCANIC (*Vulcanus*, god of fire).—Igneous action apparent at the surface of the earth, in contradistinction to *Plutonic* (which see), or that taking place at great depths in the interior. *Volcanic*, as applied to rocks, embraces all igneous products of recent or modern origin, as distinct from *Trappean* and *Granitic*.

VOLCANIC FOCI (Lat. *focus*, a fire, the point of greatest intensity).—Subterranean centres of igneous action from which minor exhibitions diverge.

VOLCANO (Lat. *Vulcanus*, the god of fire).—A volcano has been described by Sir Charles Lyell "as a more or less perfectly conical hill or mountain, formed by the successive accumulations of ejected matter in a state of incandescence or high heat, and having one or more channels of communication with the interior of the earth, by which the ejections are effected."

W

WATERSPOUT.—"The waterspouts so frequently seen in the ocean originate," says Mrs Somerville, "in adjacent strata of air of different temperatures, running in opposite directions in the upper regions of the atmosphere. They condense the vapour give it a whirling motion, so that it is tapering to the sea because the surface of the air is in a pointed spiral from above, and then inverted cones, because middle than either side. When a waterspout is in motion, the upper part moves in the direction of the wind with equal velo-

city, otherwise it breaks, which frequently happens."

WEATHER-GLASS.—The familiar name for the barometer, whose variations usually indicate approaching changes in the state of the weather.

WHIRLPOOL.—Any rotatory or circular motion of water produced by opposing winds and tides. The whirlpool of Maelström, on the coast of Norway, is occasioned by the meeting of tidal currents round the islands of Lofoden and Moskoe. It is a mile and a half in diameter, and so violent that its force is the distance of several miles.

A name given to aerial currents, and a rotatory, whirl-

ing, or spiral motion. They are often of great violence, but fortunately of short duration, and are most frequently caused by the meeting of two contrary winds, though sometimes by obstructions of the land, as precipitous mountains, narrow gorges, and the like. Their occurrence at sea produces *waterpots*; on the loose sands of the desert, *sand-pillars*, and kindred phenomena.

WIND (Sax.).—The general name for aerial currents caused by the unequal heating of the atmosphere—the heated and more rarefied portions ascending,

and the colder and denser flowing inwards to supply their place. Winds are divisible into three great categories—*permanent*, like the trade-winds; *periodical*, like the monsoons and the sea and land breezes; and *accidental*, when the times of their occurrence cannot be determined.

WINDWARD.—In nautical phraseology, all objects on the weather-side of a vessel, or that against which the wind blows, are said to be to the *windward*—that is, in the direction from which the wind blows.—See *Leeward*.

Z

ZENITH (Arabic).—In Astronomy, that point in the heavens which is vertically or right above the head of the spectator; the term *nadir* being that which denotes the opposite point, or that perpendicularly or right under his feet.

ZODIAC (*zodion*, a little animal).—The name given by astronomers to the zone within which the apparent motions of the sun, moon, and all the greater planets are performed. It constitutes a belt nine degrees on either side of the ecliptic, and is so named from its containing the figures of the animals, &c., which represent the twelve signs.—See *Signs of the Zodiac*.

ZONE, in Geography (Gr. *zona*, a girdle).—One of the five great belts into which the earth is supposed to be divided in respect to temperature—viz. the *torrid*, two *temperate*, and two *frigid* zones. The torrid includes all the space that lies between the tropics, or 23½ degrees on each side of the equinoctial line; the temperate from that limit to the arctic circle (66½ degrees) in each hemisphere; and the frigid zones from the Arctic circles to either pole.

ZONE, in Botany.—With a view to generalise their observations on the geographical distribution of indigenous plants, botanists are in the habit of

dividing the horizontal range of vegetation into *zones*, bounded by annual isothermal lines, as—1, the equatorial; 2, tropical; 3, sub-tropical; 4, warmer temperate; 5, cooler temperate; 6, sub-arctic; 7, arctic; and 8, the polar. These zones, being applicable to either hemisphere, express the climatic facies of vegetation within more precise limits than the three great zones—torrid, temperate and frigid—of the geographer.

ZONE, in Zoology.—Every zone, from the shore daily covered by the tides to the greatest vital depths, being characterised by its own peculiar seaweeds and shell-fish, in a manner very analogous to the changes in the forms and species of vegetation observed in the ascent of a tropical mountain, zoologists are in the habit of speaking of certain bathymetrical zones or “zones of life regulated by depth.” Thus, in the British seas, naturalists (following the late Edward Forbes) point out four great belts of life—the *Littoral*, the *Laminarian*, the *Coral-line*, and the *Coral* (which see); or applying the principle to the life of the ocean in general, they distinguish five great belts of depth—viz. 1, the *Littoral*; 2, *Circum-littoral*; 3, *Median*; 4, *Infra-median*; and 5, the *Abyssal* or *Deep-sea zone*.

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